US008639813B2

(12) **United States Patent**
Suganthi et al.

(10) **Patent No.: US 8,639,813 B2**
(45) **Date of Patent: Jan. 28, 2014**

(54) **SYSTEMS AND METHODS FOR GSLB BASED ON SSL VPN USERS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 998 days.

(21) Appl. No.: **12/323,153**

(22) Filed: **Nov. 25, 2008**

(65) **Prior Publication Data**

US 2010/0131960 A1 May 27, 2010

(51) **Int. Cl.**
G06F 15/173 (2006.01)

(52) **U.S. Cl.**
USPC **709/226**; 709/225

(58) **Field of Classification Search**
USPC 709/223–245
See application file for complete search history.

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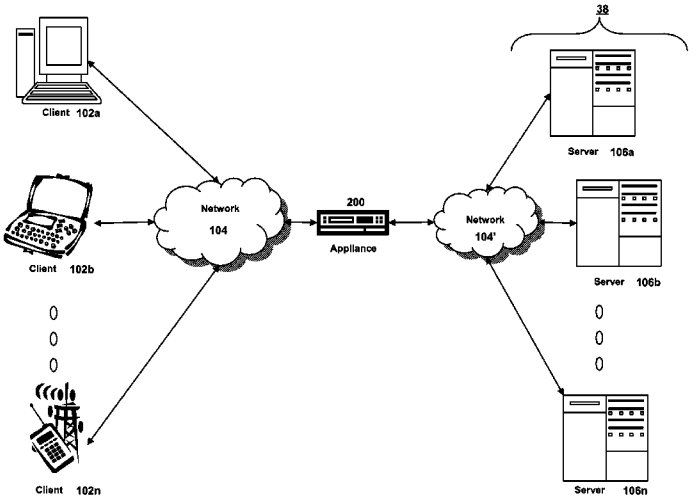
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

The present invention provides a system and a method for global server load balancing of a plurality of sites based on a number of Secure Socket Layer Virtual Private Network (SSL VPN) users. The SSL VPN users may access servers at each of the plurality of sites. A global server load balancing virtual server (GSLB) may receive a request to access a server. The GSLB virtual server may load balance a plurality of sites wherein each of the plurality of sites may further comprising a load balancing virtual server load balancing users accessing the server accessing servers via an SSL VPN session. GSLB may receive from a first load balancing virtual server at a first site, a first number of current SSL VPN users accessing servers from the first site via SSL VPN sessions. The GSLB may also receive from a second load balancing virtual server at a second site, a second number of current SSL VPN users of the users accessing servers from the second site via SSL VPN sessions. GSLB may determine to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing SSL VPN users across the plurality of sites based on the first number of current SSL VPN users and the second number of current SSL VPN users.

19 Claims, 16 Drawing Sheets



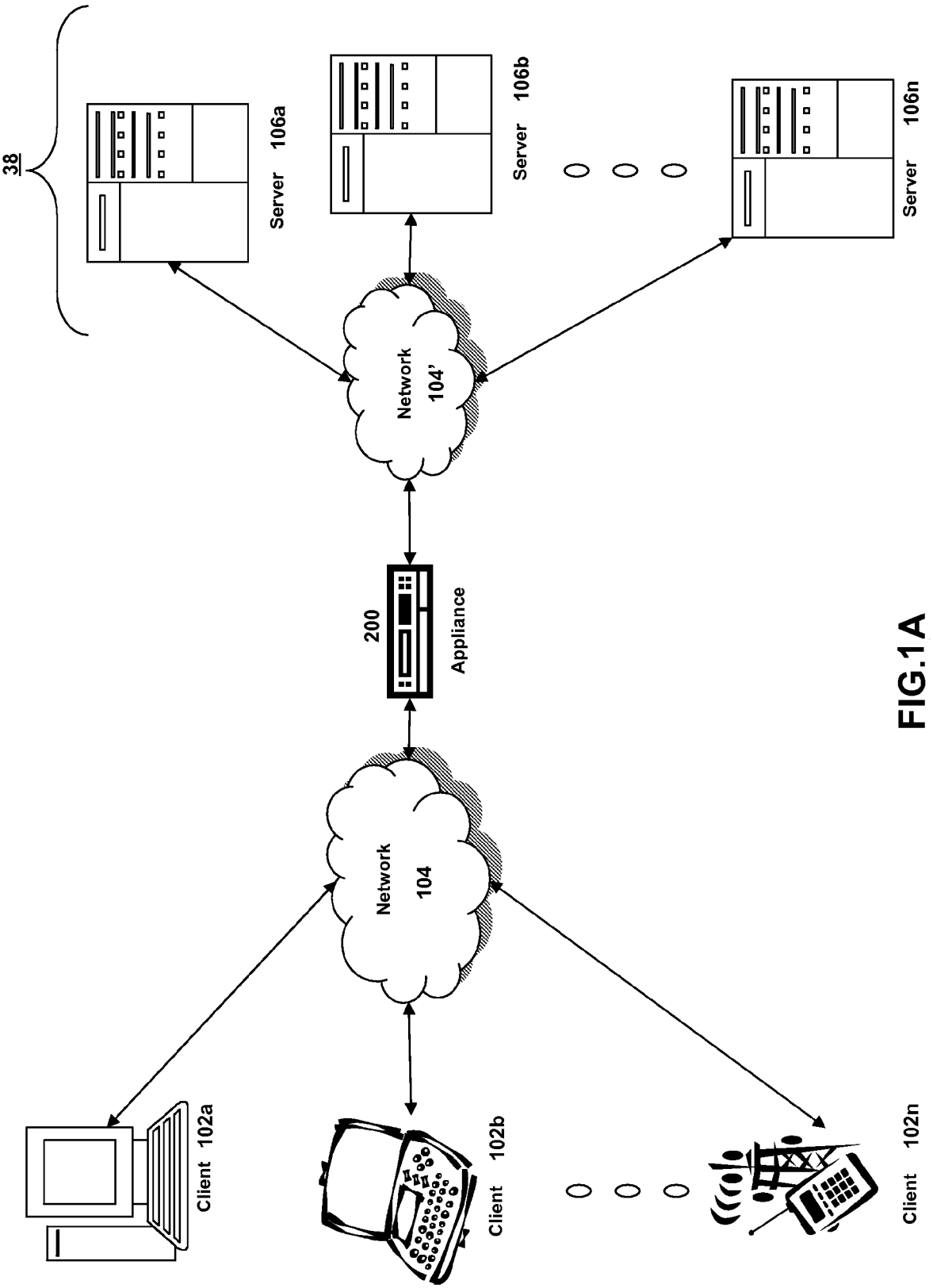

38
Server 106a
Server 106b
Server 106n
Network 104'
200
Appliance
Network 104
Client 102a
Client 102b
Client 102n

FIG.1A

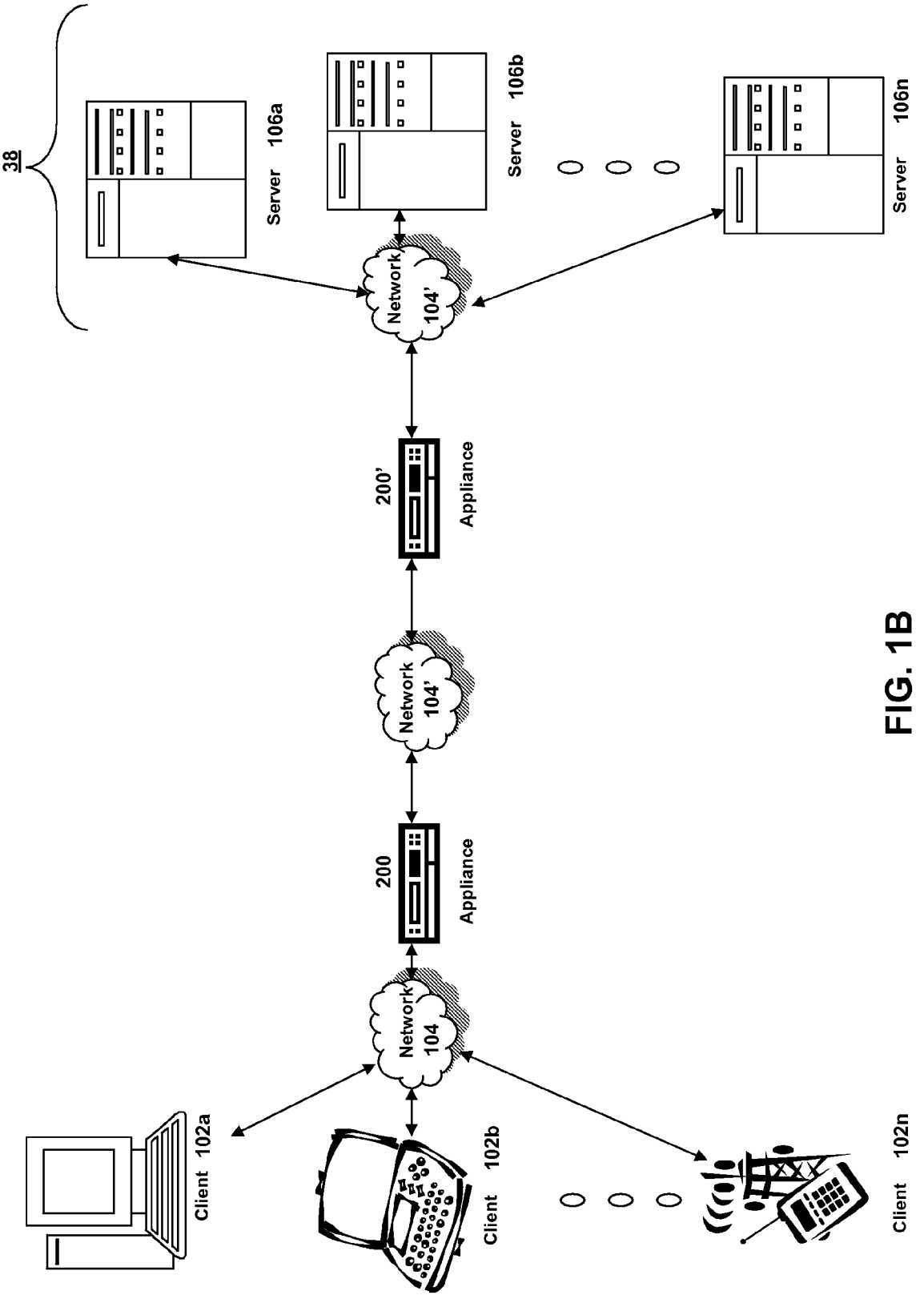

38
Server 106a
Server 106b
Server 106n
Network 104'
200' Appliance
Network 104'
200 Appliance
Network 104
Client 102a
Client 102b
Client 102n

FIG. 1B

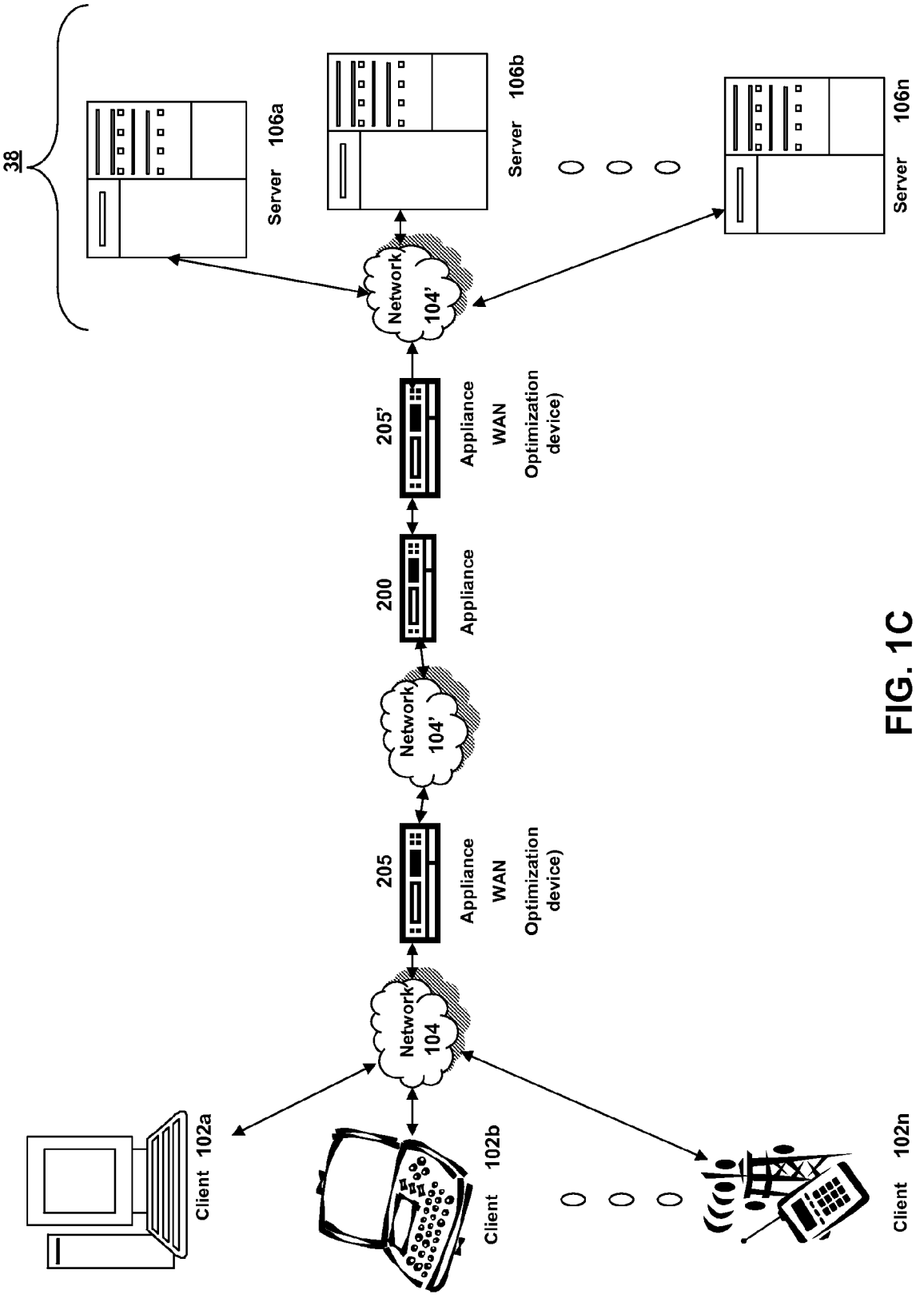

38
Server 106a
Server 106b
Server 106n
Network 104'
205' Appliance WAN Optimization device)
200 Appliance
Network 104'
205 Appliance WAN Optimization device)
Network 104
Client 102a
Client 102b
Client 102n

FIG. 1C

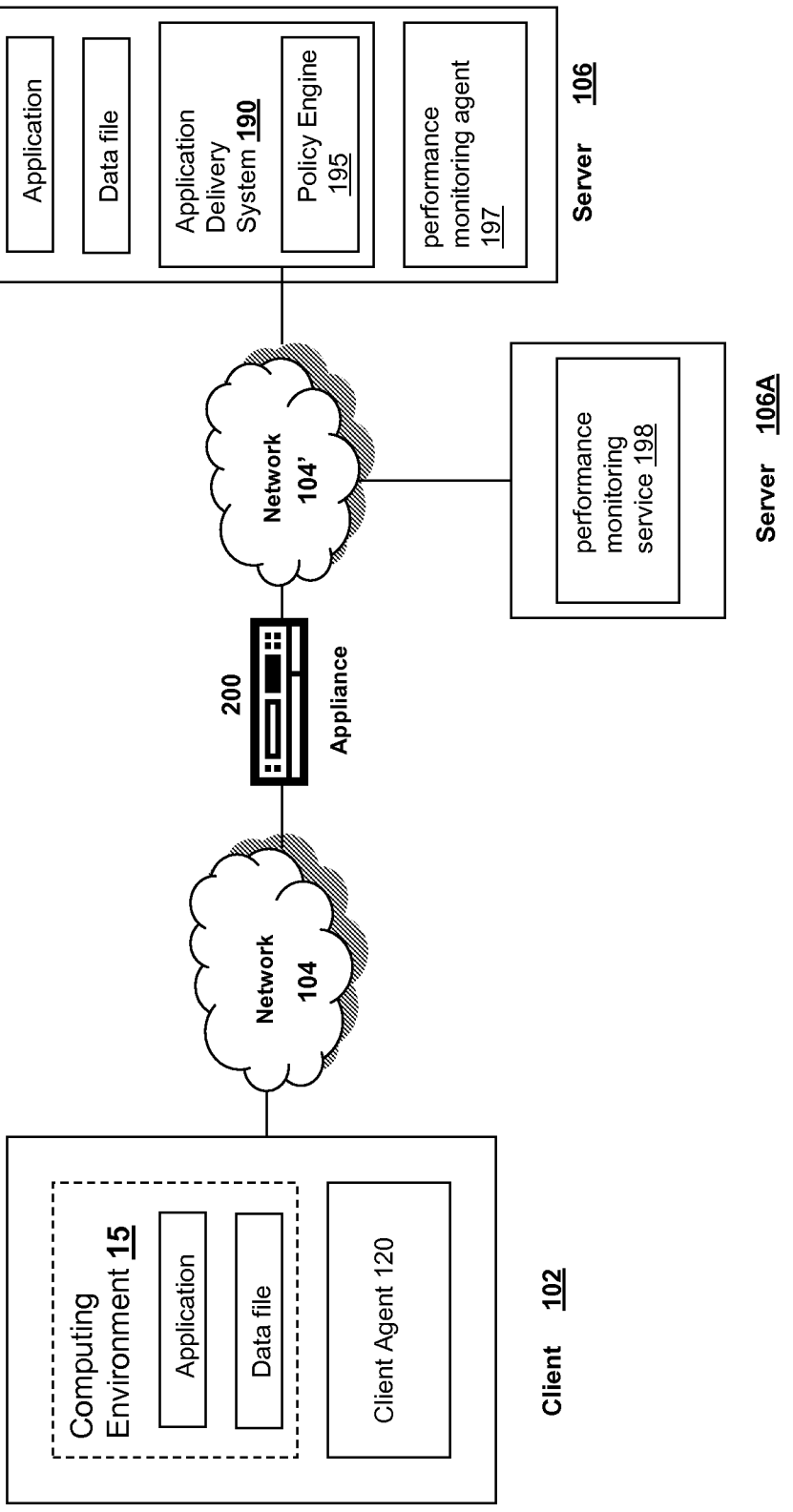

Application
Data file
Application Delivery System 190
Policy Engine 195
performance monitoring agent 197
Server 106
Network 104'
performance monitoring service 198
Server 106A
200
Appliance
Network 104
Computing Environment 15
Application
Data file
Client Agent 120
Client 102

FIG. 1D

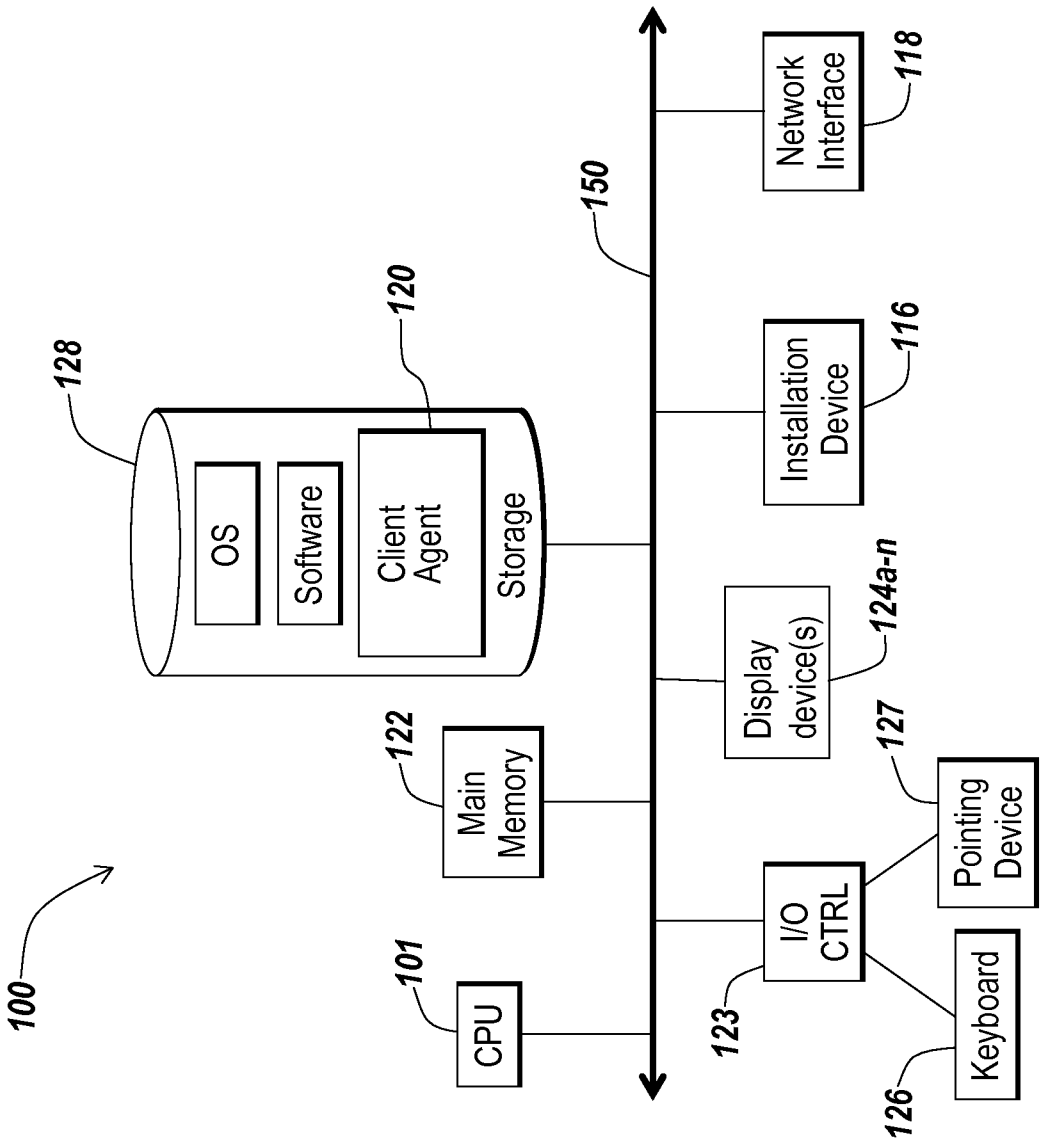

100
101
CPU
122
Main Memory
123
I/O CTRL
126
Keyboard
127
Pointing Device
124a-n
Display device(s)
116
Installation Device
118
Network Interface
150
120
Client Agent
Software
OS
128
Storage

FIG. 1E

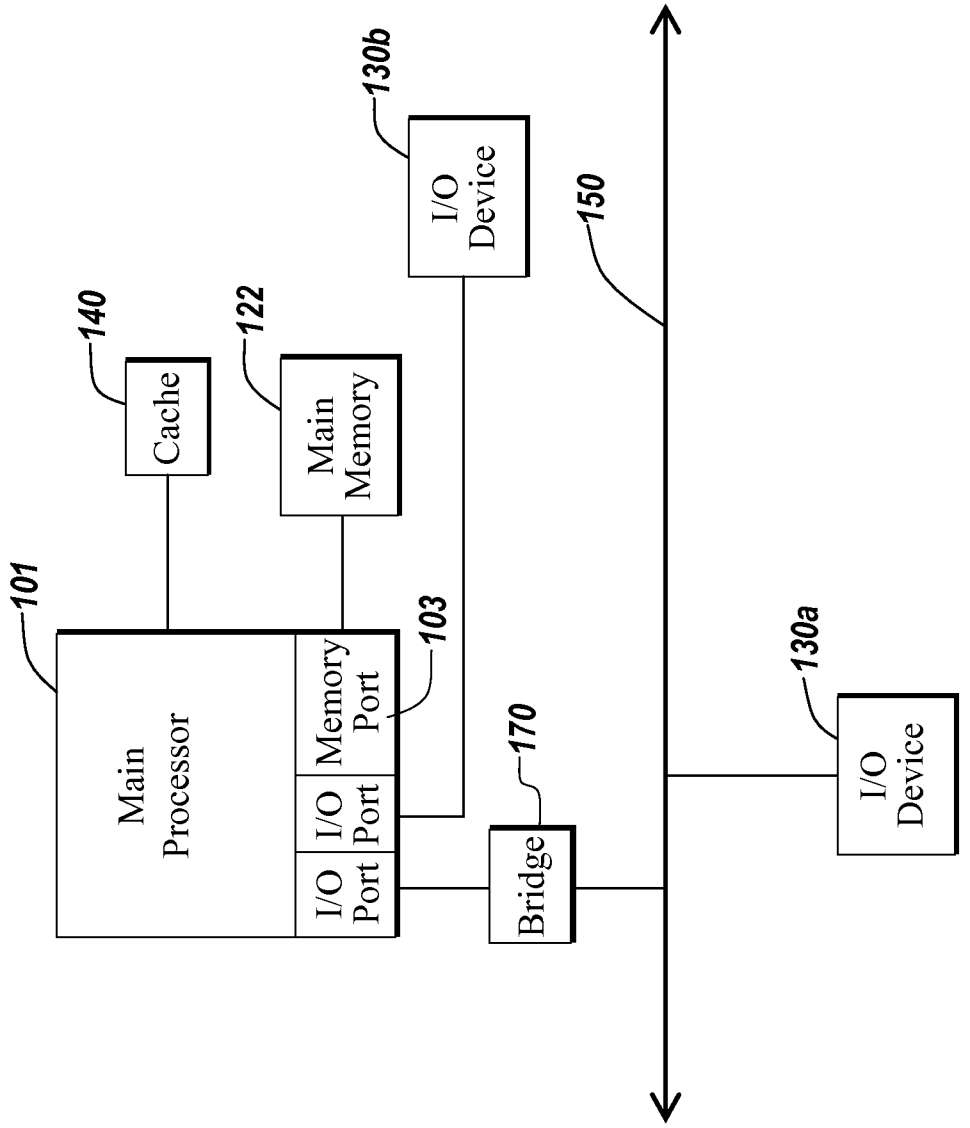

101
Main Processor
I/O Port
I/O Port
Memory Port
103
140
Cache
122
Main Memory
130b
I/O Device
150
170
Bridge
130a
I/O Device

FIG. 1F

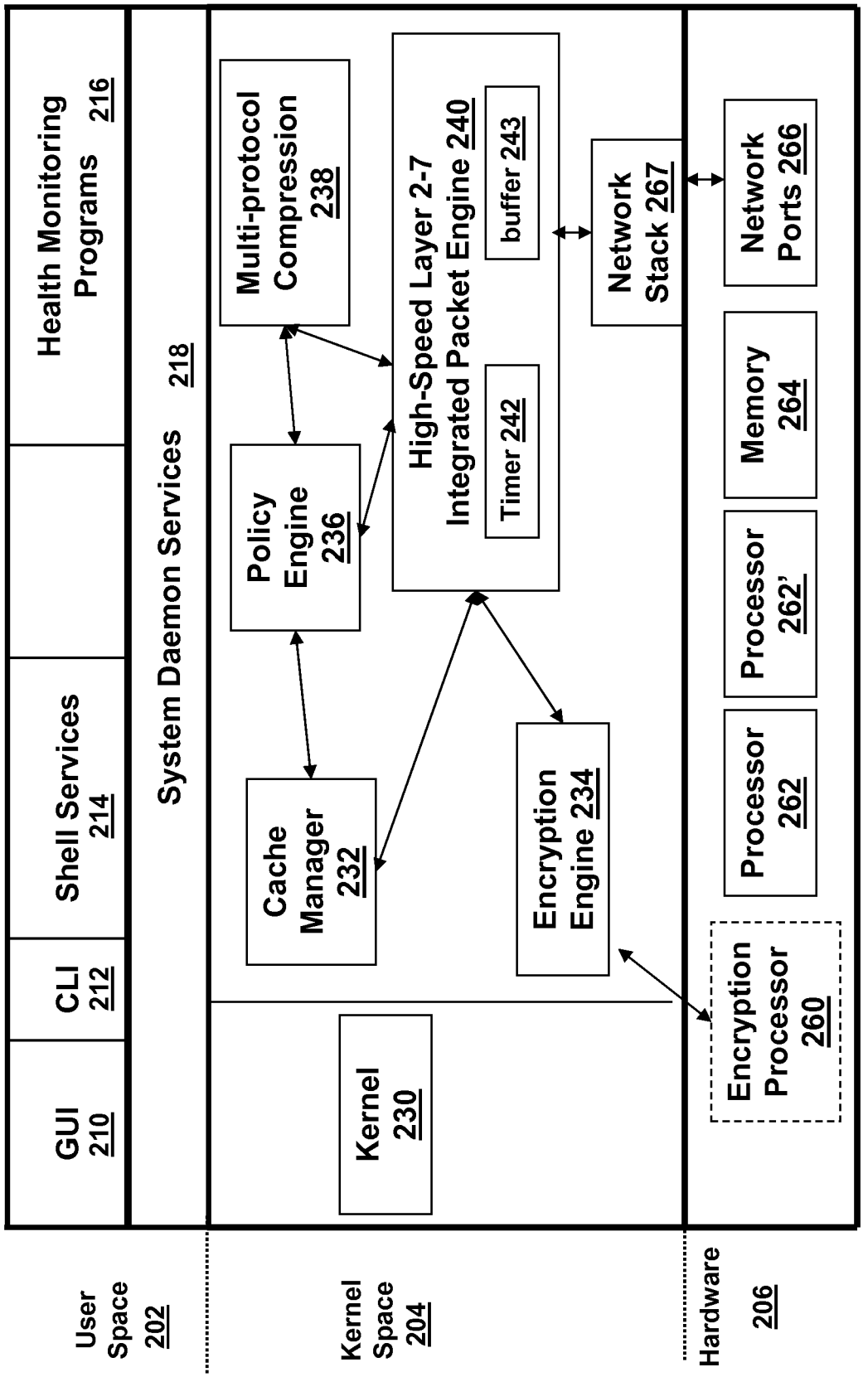

GUI 210
CLI 212
Shell Services 214
Health Monitoring Programs 216
System Daemon Services 218
Multi-protocol Compression 238
High-Speed Layer 2-7 Integrated Packet Engine 240
buffer 243
Timer 242
Network Stack 267
Network Ports 266
Policy Engine 236
Memory 264
Processor 262'
Cache Manager 232
Encryption Engine 234
Processor 262
Kernel 230
Encryption Processor 260
200
User Space 202
Kernel Space 204
Hardware 206

FIG. 2A

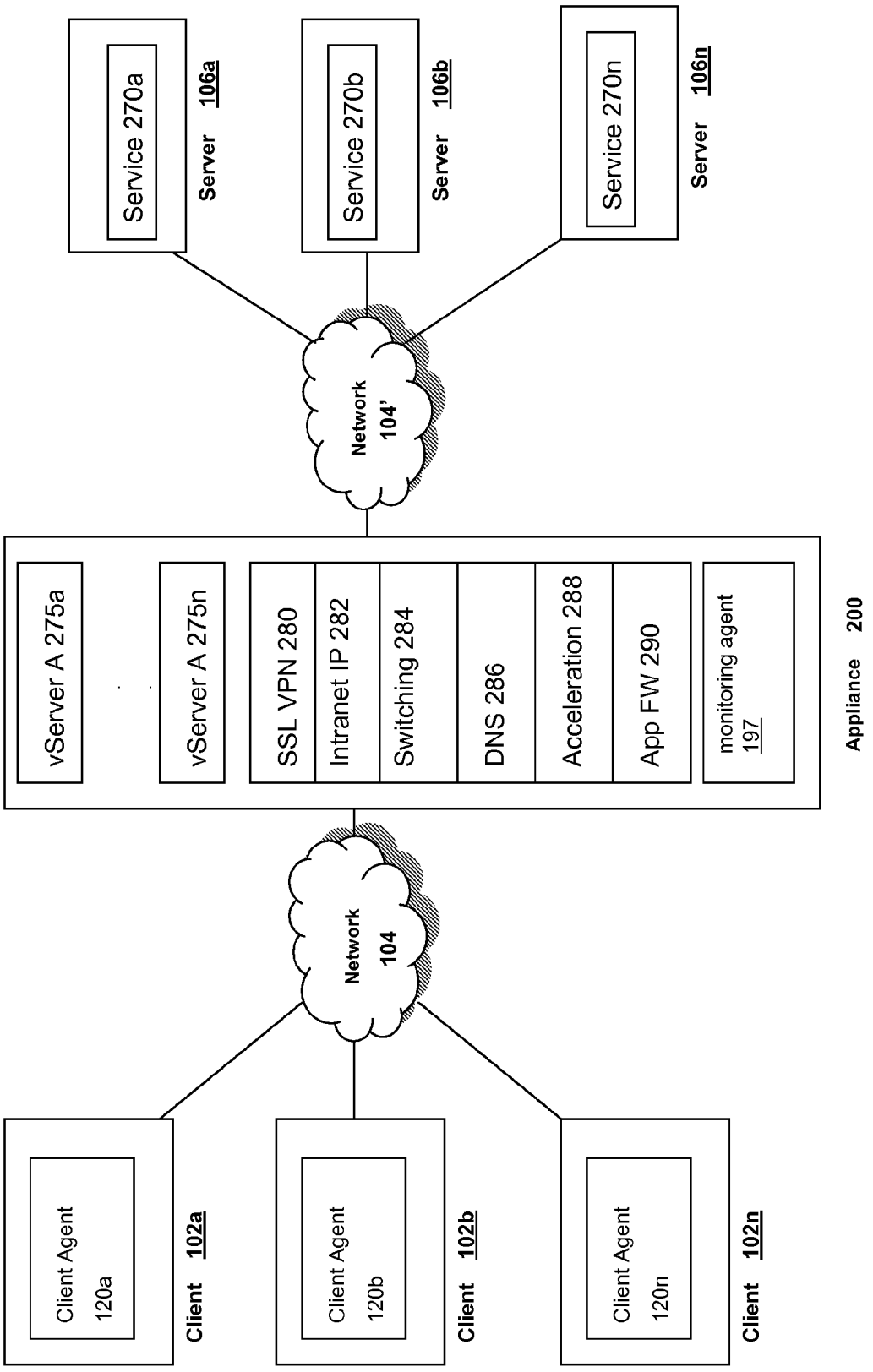

Service 270a
Server 106a
Service 270b
Server 106b
Service 270n
Server 106n
Network 104'
vServer A 275a
vServer A 275n
SSL VPN 280
Intranet IP 282
Switching 284
DNS 286
Acceleration 288
App FW 290
monitoring agent 197
Appliance 200
Network 104
Client Agent 120a
Client 102a
Client Agent 120b
Client 102b
Client Agent 120n
Client 102n

FIG. 2B

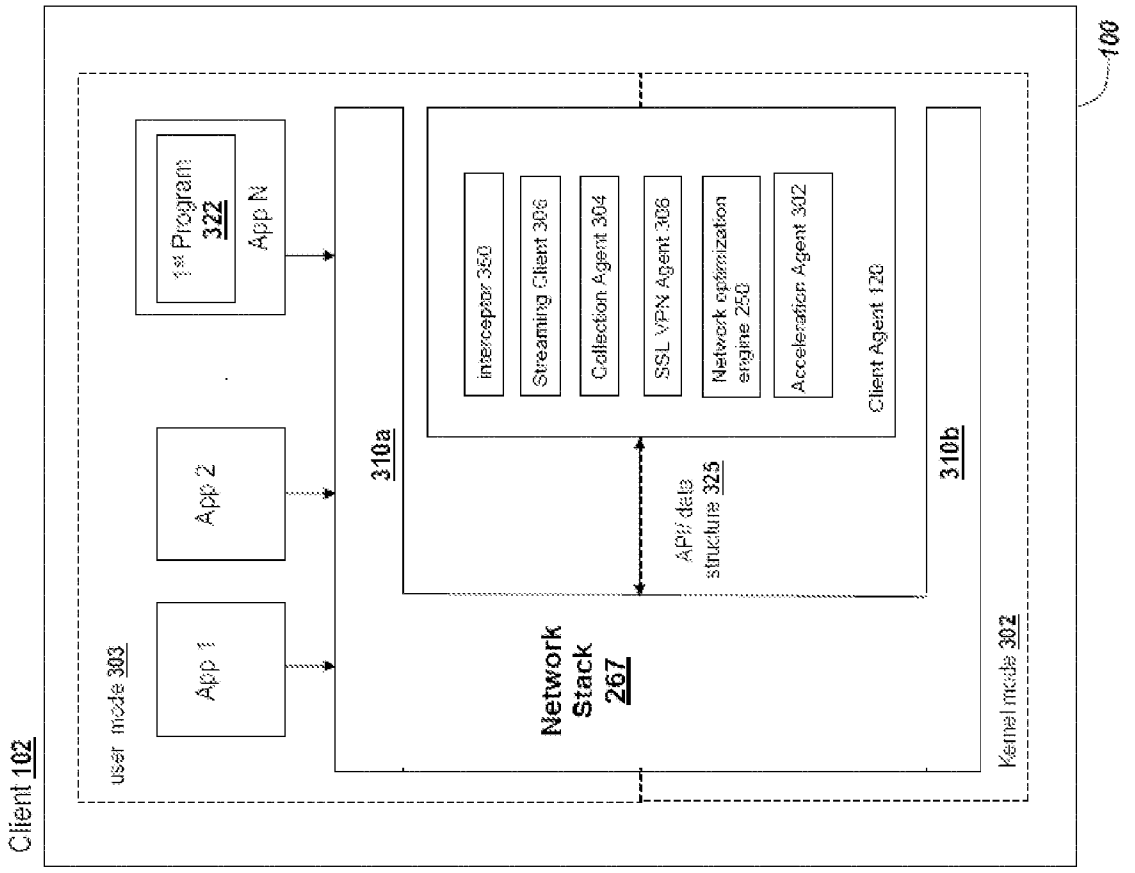

Client 102
user mode 303
App 1
App 2
1st Program 322
App N
Network Stack 267
310a
310b
Interceptor 350
Streaming Client 306
Collection Agent 304
SSL VPN Agent 306
Network optimization engine 250
Acceleration Agent 302
Client Agent 120
API data structure 325
Kernel mode 302
100

FIG. 3

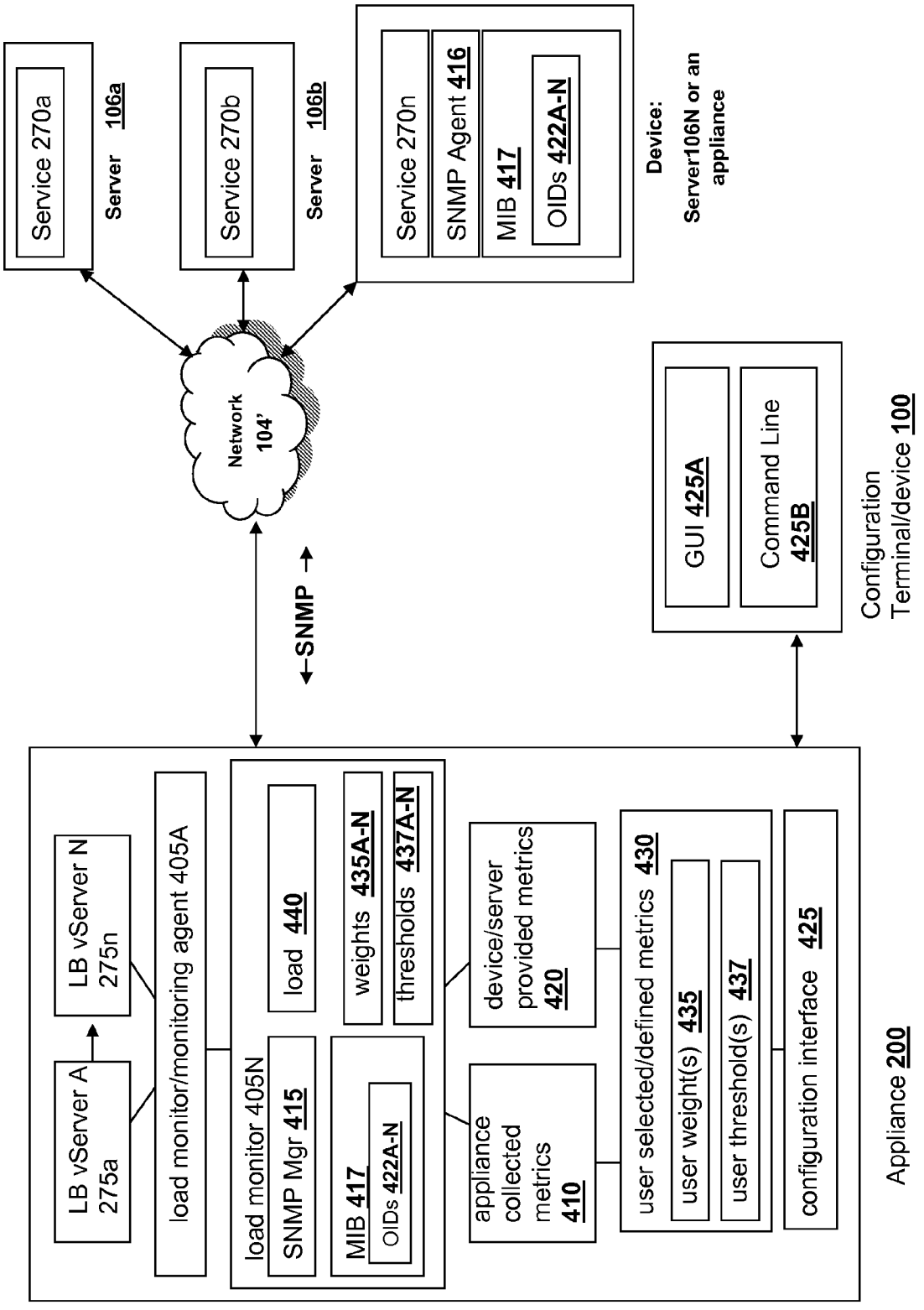

Service 270a
Server 106a
Service 270b
Server 106b
Service 270n
SNMP Agent 416
MIB 417
OIDs 422A-N
Device:
Server106N or an appliance
Network 104'
SNMP
GUI 425A
Command Line 425B
Configuration Terminal/device 100
LB vServer A 275a
LB vServer N 275n
load monitor/monitoring agent 405A
load monitor 405N
SNMP Mgr 415
MIB 417
OIDs 422A-N
load 440
weights 435A-N
thresholds 437A-N
appliance collected metrics 410
device/server provided metrics 420
user selected/defined metrics 430
user weight(s) 435
user threshold(s) 437
configuration interface 425
Appliance 200

FIG. 4A

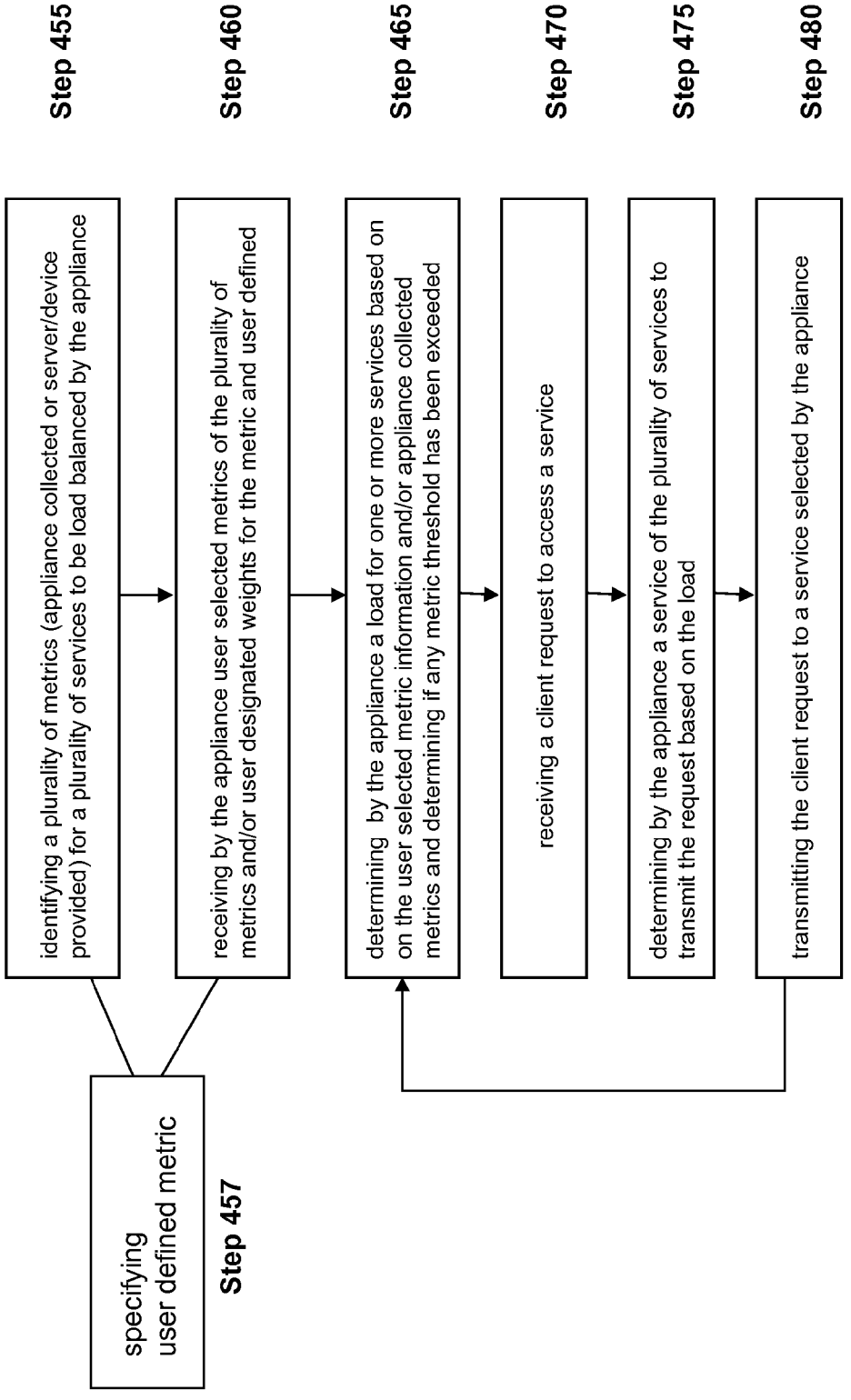

Step 455
Step 460
Step 465
Step 470
Step 475
Step 480
identifying a plurality of metrics (appliance collected or server/device provided) for a plurality of services to be load balanced by the appliance
receiving by the appliance user selected metrics of the plurality of metrics and/or user designated weights for the metric and user defined
determining by the appliance a load for one or more services based on on the user selected metric information and/or appliance collected metrics and determining if any metric threshold has been exceeded
receiving a client request to access a service
determining by the appliance a service of the plurality of services to transmit the request based on the load
transmitting the client request to a service selected by the appliance
specifying user defined metric
Step 457
450

FIG. 4B

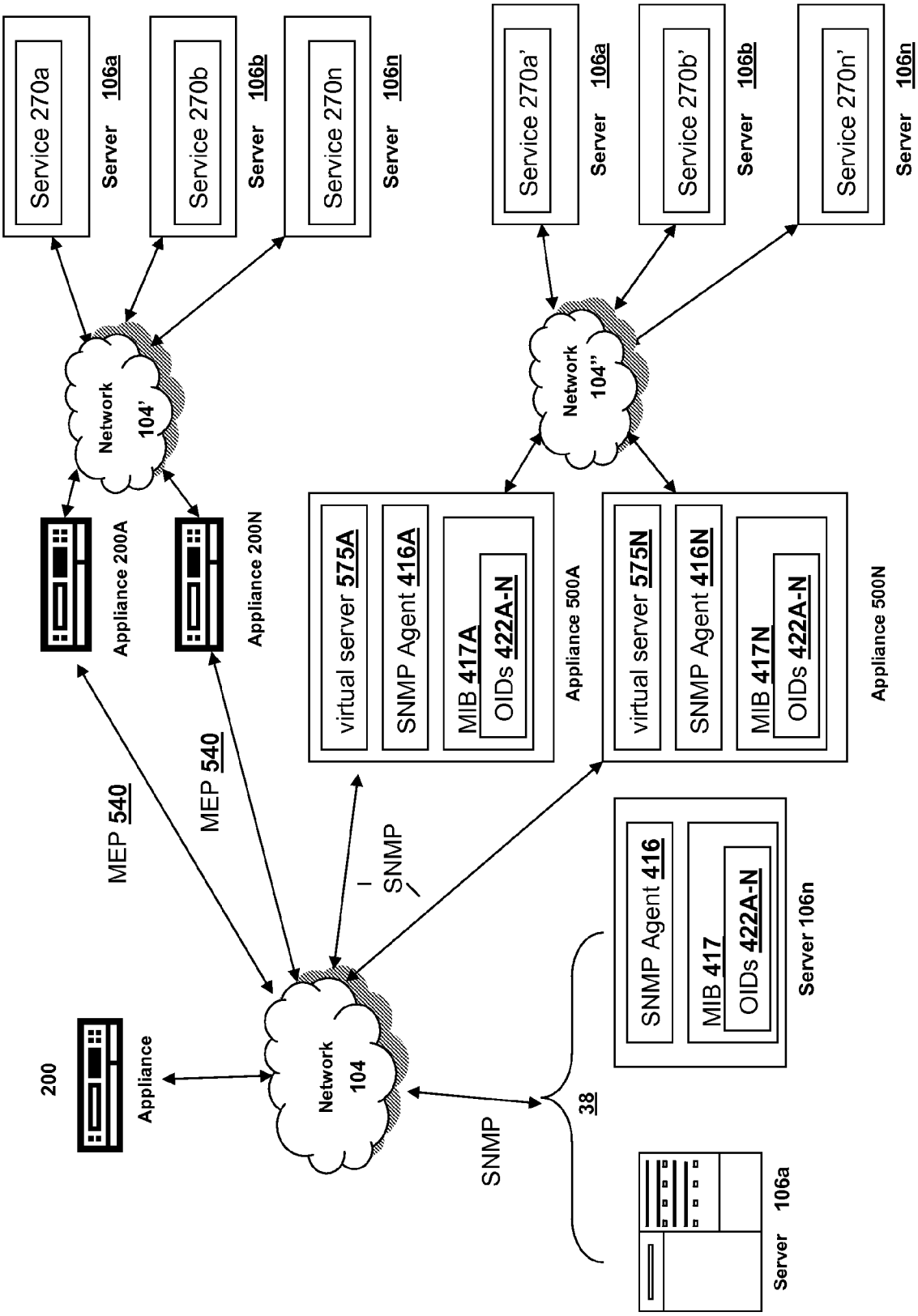

Service 270a
Server 106a
Service 270b
Server 106b
Service 270n
Server 106n
Network 104'
Appliance 200A
Appliance 200N
MEP 540
MEP 540
SNMP
virtual server 575A
SNMP Agent 416A
MIB 417A
OIDs 422A-N
Appliance 500A
Service 270a'
Server 106a
Service 270b'
Server 106b
Service 270n'
Server 106n
Network 104''
virtual server 575N
SNMP Agent 416N
MIB 417N
OIDs 422A-N
Appliance 500N
200
Appliance
Network 104
SNMP
38
SNMP Agent 416
MIB 417
OIDs 422A-N
Server 106n
Server 106a

FIG. 5A

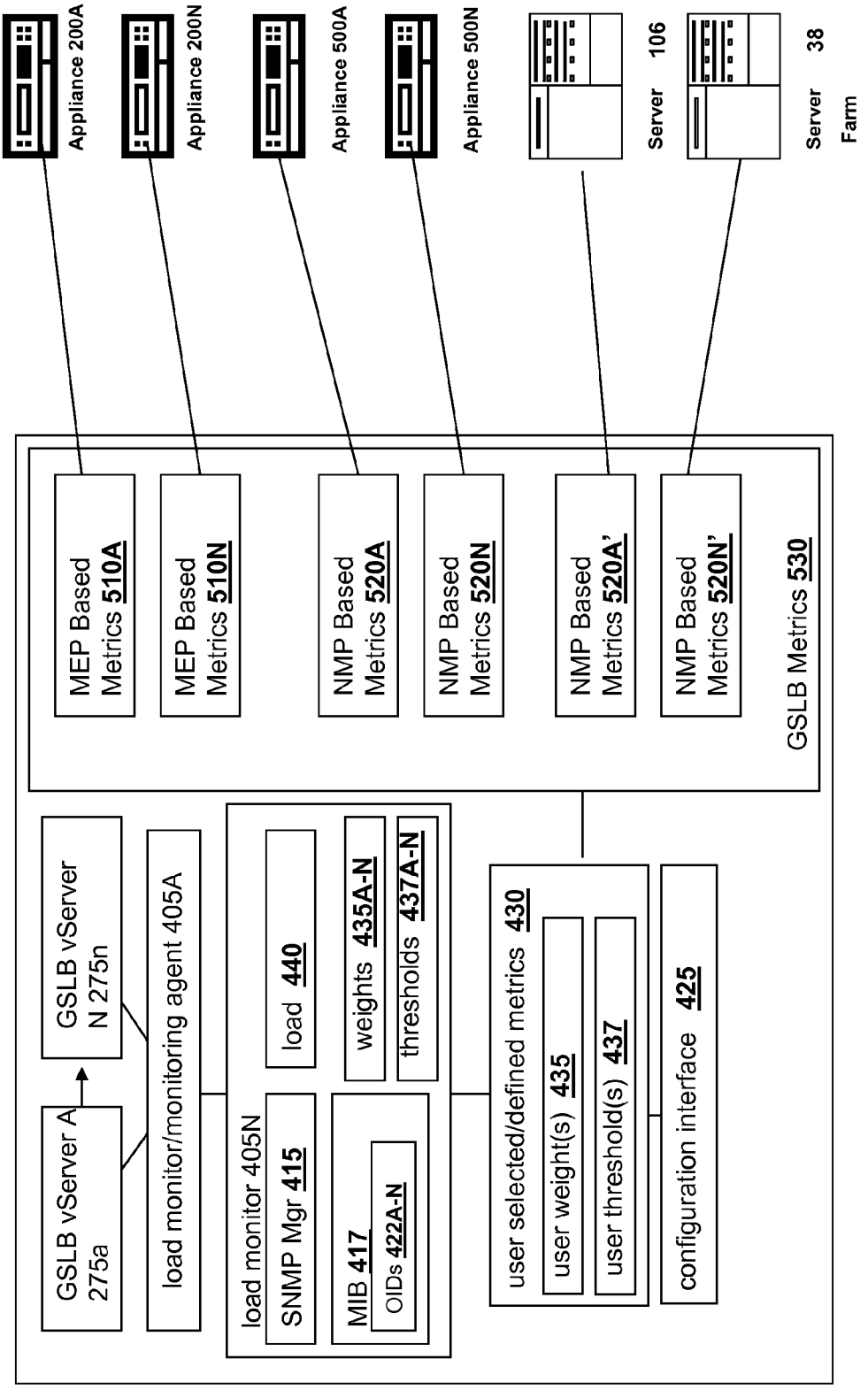

Appliance 200A
Appliance 200N
Appliance 500A
Appliance 500N
Server 106
Server 38
Farm
MEP Based Metrics 510A
MEP Based Metrics 510N
NMP Based Metrics 520A
NMP Based Metrics 520N
NMP Based Metrics 520A'
NMP Based Metrics 520N'
GSLB Metrics 530
GSLB vServer A 275a
GSLB vServer N 275n
load monitor/monitoring agent 405A
load monitor 405N
SNMP Mgr 415
MIB 417
OIDs 422A-N
load 440
weights 435A-N
thresholds 437A-N
user selected/defined metrics 430
user weight(s) 435
user threshold(s) 437
configuration interface 425
Appliance 200

FIG. 5B

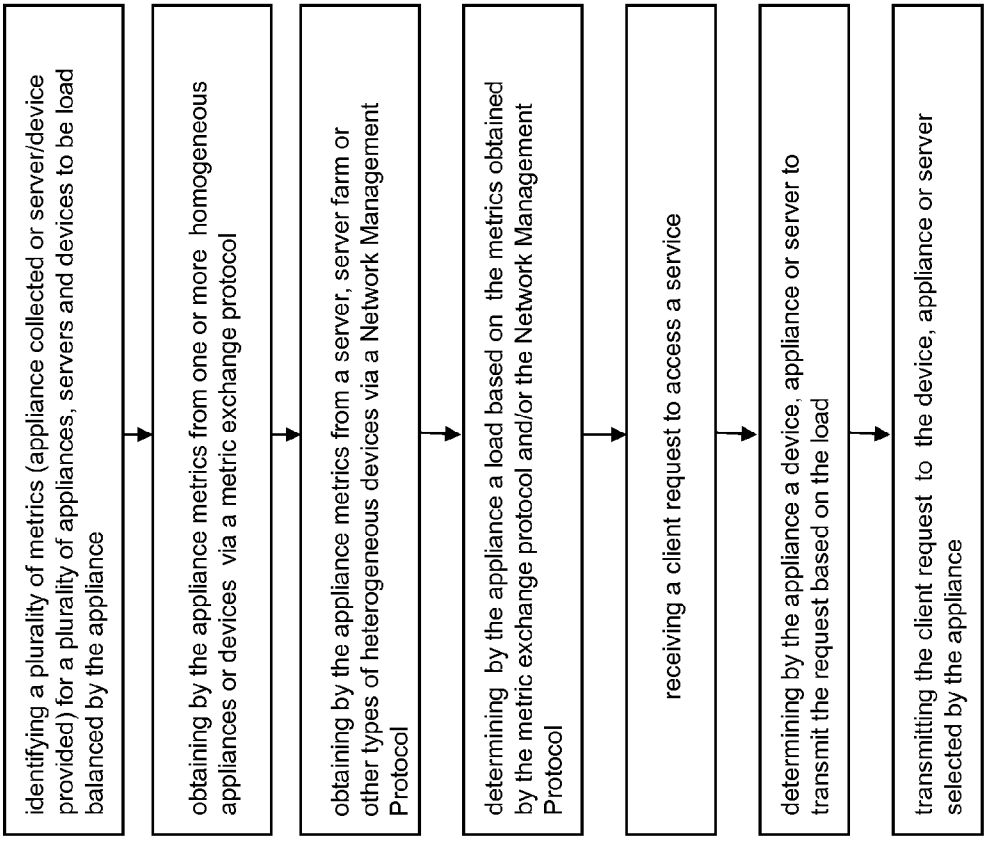

Step 555
identifying a plurality of metrics (appliance collected or server/device provided) for a plurality of appliances, servers and devices to be load balanced by the appliance
Step 560
obtaining by the appliance metrics from one or more homogeneous appliances or devices via a metric exchange protocol
Step 565
obtaining by the appliance metrics from a server, server farm or other types of heterogeneous devices via a Network Management Protocol
Step 570
determining by the appliance a load based on the metrics obtained by the metric exchange protocol and/or the Network Management Protocol
Step 575
receiving a client request to access a service
Step 580
determining by the appliance a device, appliance or server to transmit the request based on the load
Step 585
transmitting the client request to the device, appliance or server selected by the appliance
550

FIG. 5C

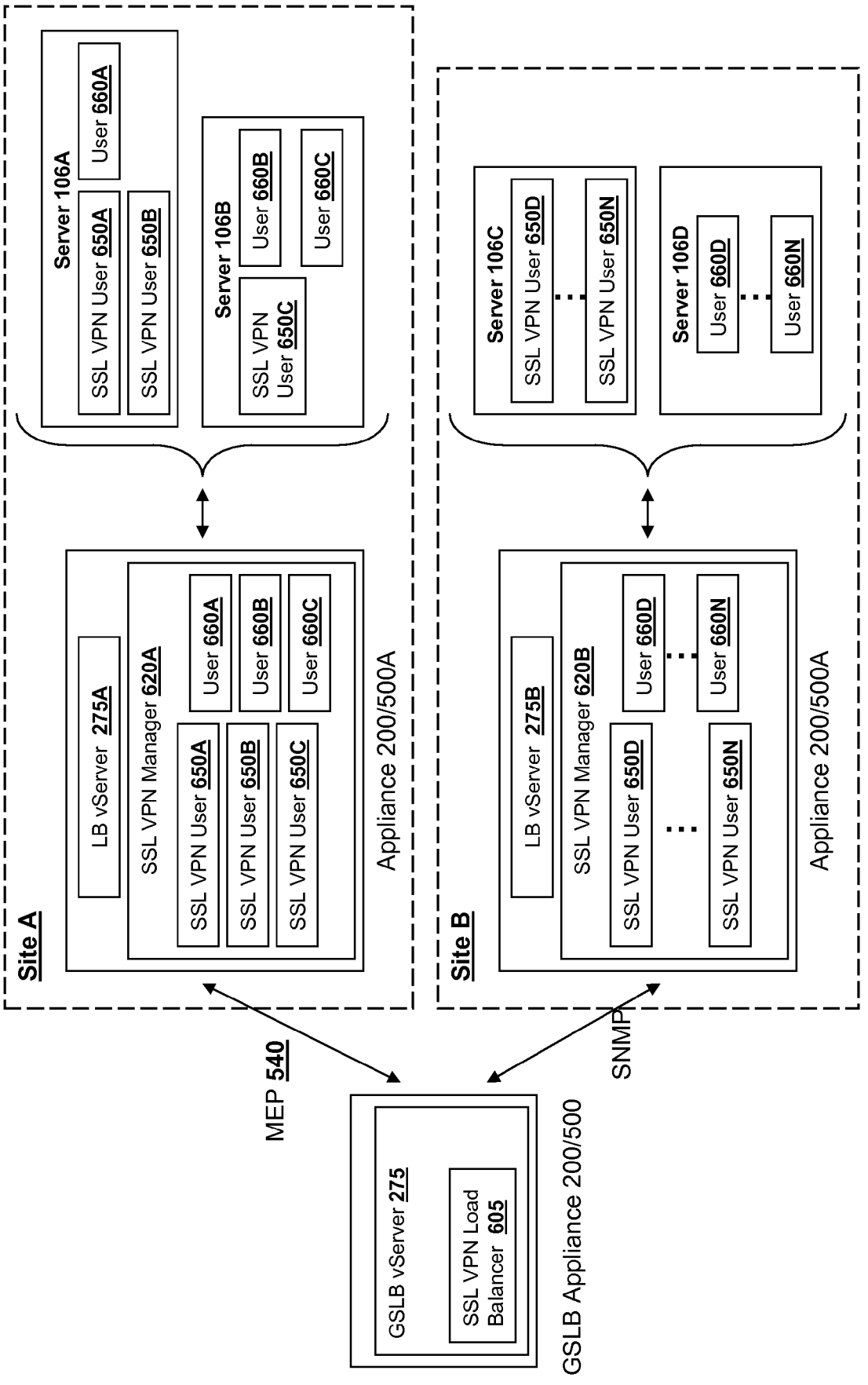

Site A
Server 106A
SSL VPN User 650A
SSL VPN User 650B
User 660A
Server 106B
SSL VPN User 650C
User 660B
User 660C
LB vServer 275A
SSL VPN Manager 620A
SSL VPN User 650A
SSL VPN User 650B
SSL VPN User 650C
User 660A
User 660B
User 660C
Appliance 200/500A
Site B
Server 106C
SSL VPN User 650D
SSL VPN User 650N
Server 106D
User 660D
User 660N
LB vServer 275B
SSL VPN Manager 620B
SSL VPN User 650D
SSL VPN User 650N
User 660D
User 660N
Appliance 200/500A
MEP 540
SNMP
GSLB vServer 275
SSL VPN Load Balancer 605
GSLB Appliance 200/500

FIG. 6A

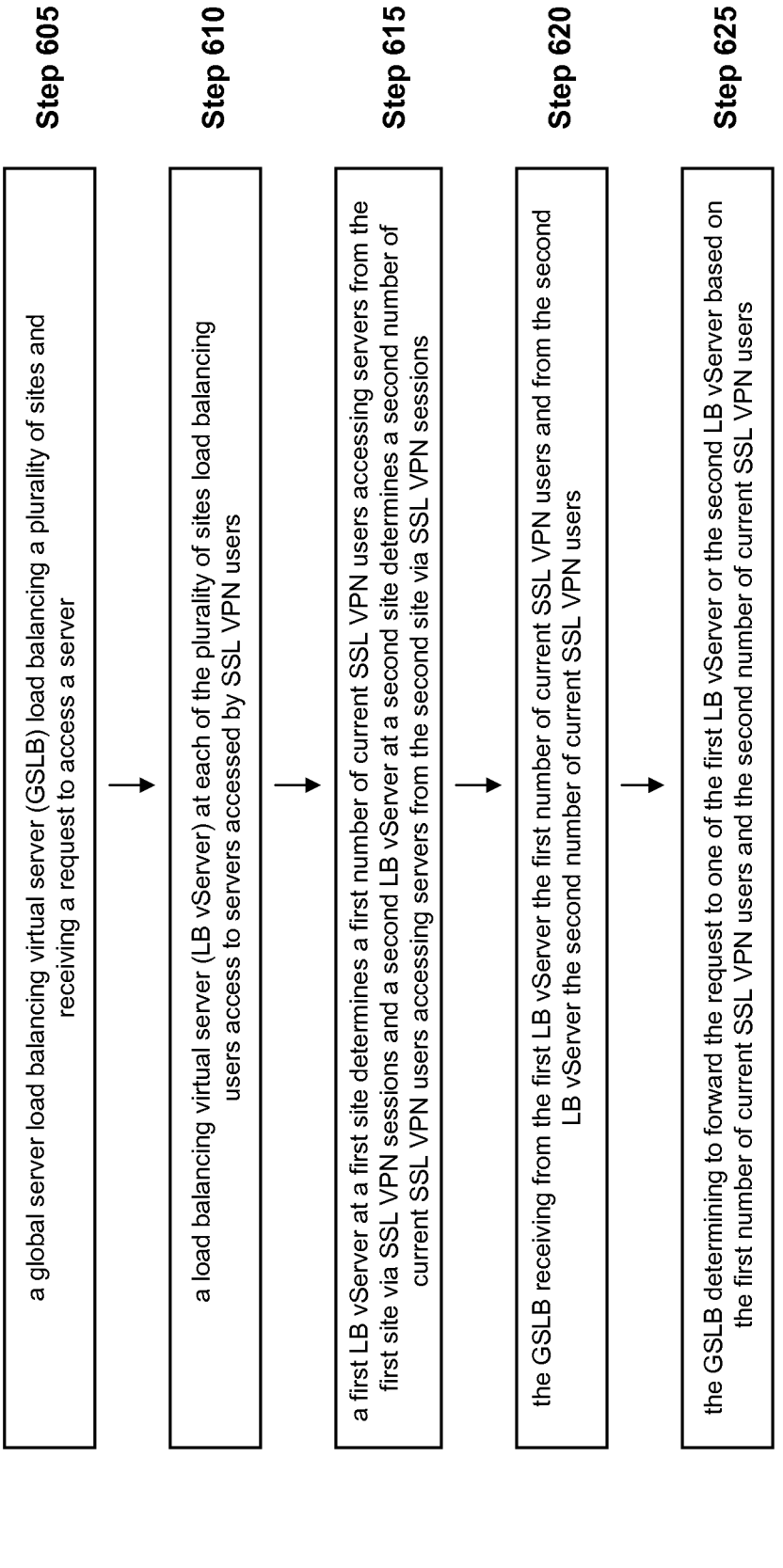

Step 605
a global server load balancing virtual server (GSLB) load balancing a plurality of sites and receiving a request to access a server
Step 610
a load balancing virtual server (LB vServer) at each of the plurality of sites load balancing users access to servers accessed by SSL VPN users
Step 615
a first LB vServer at a first site determines a first number of current SSL VPN users accessing servers from the first site via SSL VPN sessions and a second LB vServer at a second site determines a second number of current SSL VPN users accessing servers from the second site via SSL VPN sessions
Step 620
the GSLB receiving from the first LB vServer the first number of current SSL VPN users and from the second LB vServer the second number of current SSL VPN users
Step 625
the GSLB determining to forward the request to one of the first LB vServer or the second LB vServer based on the first number of current SSL VPN users and the second number of current SSL VPN users
600

FIG. 6B

SYSTEMS AND METHODS FOR GSLB BASED ON SSL VPN USERS

FIELD OF THE INVENTION

The present application generally relates to data communication networks. In particular, the present invention relates to systems and methods for load balancing network traffic across a plurality of sites based on SSL VPN users accessing the sites.

BACKGROUND OF THE INVENTION

A corporate or enterprise may deploy various services across a network to serve users from many areas. A user may use a client machine to request to access a service, such as a web server, provided by the enterprise. The enterprise in order to improve the access to this service may deploy multiple servers at various geographical locations in order to expedite the access and meet the demand of users. Similarly, the enterprise may provide a plurality of server farms positioned at a variety of sites and including any number of servers capable of processing the client's request. The enterprise may use a load balancer to manage network traffic across these servers, minimizing the network congestion and improving the service provided. Similarly, the enterprise may also use a global server load balancer (GSLB) to manage access to each of the load balancers at different sites and further help in evenly balancing the network traffic across the enterprise servers.

Any number of users may access the enterprise using different types of connections. Some users may establish connections with servers via a Secure Socket Layer Virtual Private Network (SSL VPN). Other users may establish connections with servers using connection methods other than SSL VPN. Different types of connections may use different resources of the enterprise. For example, SSL VPN connections may use different resources of the enterprise than other types of connections.

BRIEF SUMMARY OF THE INVENTION

The present invention provides improvements to load balancing by providing a load balancing solution that utilizes information identifying the number of users using SSL VPN sessions. As SSL VPN users and SSL VPN sessions may use different resources than other types of connections and users, the solution described herein provides load balancing based on a number of SSL VPN users accessing resources. A destination for an incoming request is determined based on SSL VPN user metrics obtained by the GSLB. In this manner the GSLB can load balance network traffic of the SSL VPN users across a plurality of sites.

In one aspect, the present invention relates to a method for global server load balancing of a plurality of sites based on a number of Secure Socket Layer Virtual Private Network (SSL VPN) users. The SSL VPN users may access servers at each of the plurality of sites. A global server load balancing virtual server (GSLB) may receive a request to access a server. The GSLB virtual server may load balance a plurality of sites wherein each of the plurality of sites may further comprising a load balancing virtual server load balancing users accessing the server accessing servers via an SSL VPN session. GSLB may receive from a first load balancing virtual server at a first site, a first number of current SSL VPN users accessing servers from the first site via SSL VPN sessions. The GSLB may also receive from a second load balancing virtual server at a second site, a second number of current SSL VPN users of the users accessing servers from the second site via SSL VPN sessions. The GSLB virtual server may determine to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing SSL VPN users across the plurality of sites based on the first number of current SSL VPN users and the second number of current SSL VPN users.

In some embodiments, the GSLB virtual server of a first appliance receives the request to access the server via a SSL VPN session. In other embodiments, the first load balancing virtual server of a second appliance determines the first number of current SSL VPN users accessing servers via the second appliance. In yet other embodiments, the second load balancing virtual server of a third appliance determines the second number of current SSL VPN users access servers via the third appliance. In some embodiments, the GSLB virtual server requests a number of SSL VPN users from the first load balancing virtual server via an SNMP (Simple Network Management Protocol) request. The number of SSL VPN users may be identified via an object identifier. The first load balancing virtual server may update a value of an object identified by the object identifier. In some embodiments, GSLB virtual server receives the first number of current SSL VPN users from the first load balancing virtual server of a second appliance via a metric exchange protocol communicated between the first appliance and the second appliance. In further embodiments, GSLB virtual servers requests a number of SSL VPN users from the second load balancing virtual server via an SNMP (Simple Network Management Protocol) request. The number of SSL VPN users may be identified via an object identifier. The second load balancing virtual server may update a value of an object identified by the object identifier. The first virtual load balancer of the first appliance may determine the first number of SSL VPN users from all users accessing the first site via the first appliance. The second virtual load balancer of a second appliance may determine the first number of SSL VPN users from all users accessing the second site via the second appliance. In some embodiments, the GSLB determines a threshold of a maximum number of SSL VPN users for the first site has been reached and responsive to the determination, forwards the request to the second site. In other embodiments, the GSLB virtual server determines that a threshold of a maximum number of SSL VPN users for the second site has been reached and responsive to the determination, forwards the request to the first site.

In some embodiments, the GSLB virtual server determines to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing SSL VPN users across the plurality of sites in combination with any of the following load balancing methods: least connection, least response time, least bandwidth, least packets and round trip time.

BRIEF DESCRIPTION OF THE FIGURES

The foregoing and other objects, aspects, features, and advantages of the invention will become more apparent and better understood by referring to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1**A is a block diagram of an embodiment of a network environment for a client to access a server via an appliance;

FIG. **1**B is a block diagram of an embodiment of an environment for delivering a computing environment from a server to a client via an appliance;

FIG. 1C is a block diagram of an embodiment of an environment for delivering a computing environment from a server to a client via a network;

FIG. 1D is a block diagram of another embodiment of an environment for delivering a computing environment from a server to a client via a network.

FIGS. 1E and 1F are block diagrams of embodiments of a computing device;

FIG. 2A is a block diagram of an embodiment of an appliance for processing communications between a client and a server;

FIG. 2B is a block diagram of another embodiment of an appliance for optimizing, accelerating, load-balancing and routing communications between a client and a server;

FIG. 3 is a block diagram of an embodiment of a client for communicating with a server via the appliance;

FIG. 4A is a block diagram of an embodiment of an appliance for collecting metrics via a network management protocol and for determining a load of services based on user selected metrics;

FIG. 4B is a flow diagram of an embodiment of steps of a method for performing load balancing based on user selected metrics in view of FIG. 4B;

FIG. 5A is a block diagram of an embodiment of a network environment for performing global server load balancing among heterogeneous devices;

FIG. 5B is a block diagram of an embodiment of an appliance performing server load balancing among heterogeneous devices;

FIG. 5C is a flow diagram of an embodiment of steps of a method for Global Server Load Balancing among heterogeneous devices;

FIG. 6A is a block diagram of an embodiment of a system for load balancing of user requests using SSL VPN user information; and

FIG. 6B is a flow diagram of an embodiment of steps of a method for global server load balancing of a plurality of sites based on a number of SSL VPN users accessing servers at each of the plurality sites.

The features and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings, in which like reference characters identify corresponding elements throughout. In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements.

DETAILED DESCRIPTION OF THE INVENTION

For purposes of reading the description of the various embodiments of the present invention below, the following descriptions of the sections of the specification and their respective contents may be helpful:

Section A describes a network environment and computing environment useful for practicing an embodiment of the present invention;

Section B describes embodiments of a system and appliance architecture for accelerating delivery of a computing environment to a remote user;

Section C describes embodiments of a client agent for accelerating communications between a client and a server;

Section D describes embodiments of systems and methods for load balancing based on metrics selected by a user from appliance determined metrics and/or metrics collected from a device via a Simple Network Management Protocol; and

Section E describes embodiments of systems and methods for global server load balancing among heterogeneous devices.

Section F describes global server load balancing based on SSL VPN user information.

A. Network and Computing Environment

Prior to discussing the specifics of embodiments of the systems and methods of an appliance and/or client, it may be helpful to discuss the network and computing environments in which such embodiments may be deployed. Referring now to FIG. 1A, an embodiment of a network environment is depicted. In brief overview, the network environment comprises one or more clients **102***a*-**102***n* (also generally referred to as local machine(s) **102**, or client(s) **102**) in communication with one or more servers **106***a*-**106***n* (also generally referred to as server(s) **106**, or remote machine(s) **106**) via one or more networks **104**, **104'** (generally referred to as network **104**). In some embodiments, a client **102** communicates with a server **106** via an appliance **200**.

Although FIG. 1A shows a network **104** and a network **104'** between the clients **102** and the servers **106**, the clients **102** and the servers **106** may be on the same network **104**. The networks **104** and **104'** can be the same type of network or different types of networks. The network **104** and/or the network **104'** can be a local-area network (LAN), such as a company Intranet, a metropolitan area network (MAN), or a wide area network (WAN), such as the Internet or the World Wide Web. In one embodiment, network **104'** may be a private network and network **104** may be a public network. In some embodiments, network **104** may be a private network and network **104'** a public network. In another embodiment, networks **104** and **104'** may both be private networks. In some embodiments, clients **102** may be located at a branch office of a corporate enterprise communicating via a WAN connection over the network **104** to the servers **106** located at a corporate data center.

The network **104** and/or **104'** be any type and/or form of network and may include any of the following: a point to point network, a broadcast network, a wide area network, a local area network, a telecommunications network, a data communication network, a computer network, an ATM (Asynchronous Transfer Mode) network, a SONET (Synchronous Optical Network) network, a SDH (Synchronous Digital Hierarchy) network, a wireless network and a wireline network. In some embodiments, the network **104** may comprise a wireless link, such as an infrared channel or satellite band. The topology of the network **104** and/or **104'** may be a bus, star, or ring network topology. The network **104** and/or **104'** and network topology may be of any such network or network topology as known to those ordinarily skilled in the art capable of supporting the operations described herein.

As shown in FIG. 1A, the appliance **200**, which also may be referred to as an interface unit **200** or gateway **200**, is shown between the networks **104** and **104'**. In some embodiments, the appliance **200** may be located on network **104**. For example, a branch office of a corporate enterprise may deploy an appliance **200** at the branch office. In other embodiments, the appliance **200** may be located on network **104'**. For example, an appliance **200** may be located at a corporate data center. In yet another embodiment, a plurality of appliances **200** may be deployed on network **104**. In some embodiments, a plurality of appliances **200** may be deployed on network **104'**. In one embodiment, a first appliance **200** communicates with a second appliance **200'**. In other embodiments, the appliance **200** could be a part of any client **102** or server **106** on the same or different network **104**,**104'** as the client **102**.

One or more appliances **200** may be located at any point in the network or network communications path between a client **102** and a server **106**.

In some embodiments, the appliance **200** comprises any of the network devices manufactured by Citrix Systems, Inc. of Ft. Lauderdale Fla., referred to as Citrix NetScaler devices. In other embodiments, the appliance **200** includes any of the product embodiments referred to as WebAccelerator and BigIP manufactured by F5 Networks, Inc. of Seattle, Wash. In another embodiment, the appliance **205** includes any of the DX acceleration device platforms and/or the SSL VPN series of devices, such as SA 700, SA 2000, SA 4000, and SA 6000 devices manufactured by Juniper Networks, Inc. of Sunnyvale, Calif. In yet another embodiment, the appliance **200** includes any application acceleration and/or security related appliances and/or software manufactured by Cisco Systems, Inc. of San Jose, Calif., such as the Cisco ACE Application Control Engine Module service software and network modules, and Cisco AVS Series Application Velocity System.

In one embodiment, the system may include multiple, logically-grouped servers **106**. In these embodiments, the logical group of servers may be referred to as a server farm **38**. In some of these embodiments, the serves **106** may be geographically dispersed. In some cases, a farm **38** may be administered as a single entity. In other embodiments, the server farm **38** comprises a plurality of server farms **38**. In one embodiment, the server farm executes one or more applications on behalf of one or more clients **102**.

The servers **106** within each farm **38** can be heterogeneous. One or more of the servers **106** can operate according to one type of operating system platform (e.g., WINDOWS NT, manufactured by Microsoft Corp. of Redmond, Wash.), while one or more of the other servers **106** can operate on according to another type of operating system platform (e.g., Unix or Linux). The servers **106** of each farm **38** do not need to be physically proximate to another server **106** in the same farm **38**. Thus, the group of servers **106** logically grouped as a farm **38** may be interconnected using a wide-area network (WAN) connection or medium-area network (MAN) connection. For example, a farm **38** may include servers **106** physically located in different continents or different regions of a continent, country, state, city, campus, or room. Data transmission speeds between servers **106** in the farm **38** can be increased if the servers **106** are connected using a local-area network (LAN) connection or some form of direct connection.

Servers **106** may be referred to as a file server, application server, web server, proxy server, or gateway server. In some embodiments, a server **106** may have the capacity to function as either an application server or as a master application server. In one embodiment, a server **106** may include an Active Directory. The clients **102** may also be referred to as client nodes or endpoints. In some embodiments, a client **102** has the capacity to function as both a client node seeking access to applications on a server and as an application server providing access to hosted applications for other clients **102***a*-**102***n*.

In some embodiments, a client **102** communicates with a server **106**. In one embodiment, the client **102** communicates directly with one of the servers **106** in a farm **38**. In another embodiment, the client **102** executes a program neighborhood application to communicate with a server **106** in a farm **38**. In still another embodiment, the server **106** provides the functionality of a master node. In some embodiments, the client **102** communicates with the server **106** in the farm **38** through a network **104**. Over the network **104**, the client **102** can, for example, request execution of various applications hosted by the servers **106***a*-**106***n* in the farm **38** and receive output of the results of the application execution for display. In some embodiments, only the master node provides the functionality required to identify and provide address information associated with a server **106'** hosting a requested application.

In one embodiment, the server **106** provides functionality of a web server. In another embodiment, the server **106***a* receives requests from the client **102**, forwards the requests to a second server **106***b* and responds to the request by the client **102** with a response to the request from the server **106***b*. In still another embodiment, the server **106** acquires an enumeration of applications available to the client **102** and address information associated with a server **106** hosting an application identified by the enumeration of applications. In yet another embodiment, the server **106** presents the response to the request to the client **102** using a web interface. In one embodiment, the client **102** communicates directly with the server **106** to access the identified application. In another embodiment, the client **102** receives application output data, such as display data, generated by an execution of the identified application on the server **106**.

Referring now to FIG. **1**B, an embodiment of a network environment deploying multiple appliances **200** is depicted. A first appliance **200** may be deployed on a first network **104** and a second appliance **200'** on a second network **104'**. For example a corporate enterprise may deploy a first appliance **200** at a branch office and a second appliance **200'** at a data center. In another embodiment, the first appliance **200** and second appliance **200'** are deployed on the same network **104** or network **104**. For example, a first appliance **200** may be deployed for a first server farm **38**, and a second appliance **200** may be deployed for a second server farm **38'**. In another example, a first appliance **200** may be deployed at a first branch office while the second appliance **200'** is deployed at a second branch office'. In some embodiments, the first appliance **200** and second appliance **200'** work in cooperation or in conjunction with each other to accelerate network traffic or the delivery of application and data between a client and a server

Referring now to FIG. **1**C, another embodiment of a network environment deploying the appliance **200** with one or more other types of appliances, such as between one or more WAN optimization appliance **205**, **205'** is depicted. For example a first WAN optimization appliance **205** is shown between networks **104** and **104'** and s second WAN optimization appliance **205'** may be deployed between the appliance **200** and one or more servers **106**. By way of example, a corporate enterprise may deploy a first WAN optimization appliance **205** at a branch office and a second WAN optimization appliance **205'** at a data center. In some embodiments, the appliance **205** may be located on network **104'**. In other embodiments, the appliance **205'** may be located on network **104**. In some embodiments, the appliance **205'** may be located on network **104'** or network **104"**. In one embodiment, the appliance **205** and **205'** are on the same network. In another embodiment, the appliance **205** and **205'** are on different networks. In another example, a first WAN optimization appliance **205** may be deployed for a first server farm **38** and a second WAN optimization appliance **205'** for a second server farm **38'**

In one embodiment, the appliance **205** is a device for accelerating, optimizing or otherwise improving the performance, operation, or quality of service of any type and form of network traffic, such as traffic to and/or from a WAN connection. In some embodiments, the appliance **205** is a performance enhancing proxy. In other embodiments, the appliance **205** is any type and form of WAN optimization or acceleration

device, sometimes also referred to as a WAN optimization controller. In one embodiment, the appliance **205** is any of the product embodiments referred to as WANScaler manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. In other embodiments, the appliance **205** includes any of the product embodiments referred to as BIG-IP link controller and WANJet manufactured by F5 Networks, Inc. of Seattle, Wash. In another embodiment, the appliance **205** includes any of the WX and WXC WAN acceleration device platforms manufactured by Juniper Networks, Inc. of Sunnyvale, Calif. In some embodiments, the appliance **205** includes any of the steelhead line of WAN optimization appliances manufactured by Riverbed Technology of San Francisco, Calif. In other embodiments, the appliance **205** includes any of the WAN related devices manufactured by Expand Networks Inc. of Roseland, N.J. In one embodiment, the appliance **205** includes any of the WAN related appliances manufactured by Packeteer Inc. of Cupertino, Calif., such as the PacketShaper, iShared, and SkyX product embodiments provided by Packeteer. In yet another embodiment, the appliance **205** includes any WAN related appliances and/or software manufactured by Cisco Systems, Inc. of San Jose, Calif., such as the Cisco Wide Area Network Application Services software and network modules, and Wide Area Network engine appliances.

In one embodiment, the appliance **205** provides application and data acceleration services for branch-office or remote offices. In one embodiment, the appliance **205** includes optimization of Wide Area File Services (WAFS). In another embodiment, the appliance **205** accelerates the delivery of files, such as via the Common Internet File System (CIFS) protocol. In other embodiments, the appliance **205** provides caching in memory and/or storage to accelerate delivery of applications and data. In one embodiment, the appliance **205** provides compression of network traffic at any level of the network stack or at any protocol or network layer. In another embodiment, the appliance **205** provides transport layer protocol optimizations, flow control, performance enhancements or modifications and/or management to accelerate delivery of applications and data over a WAN connection. For example, in one embodiment, the appliance **205** provides Transport Control Protocol (TCP) optimizations. In other embodiments, the appliance **205** provides optimizations, flow control, performance enhancements or modifications and/or management for any session or application layer protocol.

In another embodiment, the appliance **205** encoded any type and form of data or information into custom or standard TCP and/or IP header fields or option fields of network packet to announce presence, functionality or capability to another appliance **205'**. In another embodiment, an appliance **205'** may communicate with another appliance **205'** using data encoded in both TCP and/or IP header fields or options. For example, the appliance may use TCP option(s) or IP header fields or options to communicate one or more parameters to be used by the appliances **205**, **205'** in performing functionality, such as WAN acceleration, or for working in conjunction with each other.

In some embodiments, the appliance **200** preserves any of the information encoded in TCP and/or IP header and/or option fields communicated between appliances **205** and **205'**. For example, the appliance **200** may terminate a transport layer connection traversing the appliance **200**, such as a transport layer connection from between a client and a server traversing appliances **205** and **205'**. In one embodiment, the appliance **200** identifies and preserves any encoded information in a transport layer packet transmitted by a first appliance **205** via a first transport layer connection and communicates a transport layer packet with the encoded information to a second appliance **205'** via a second transport layer connection.

Referring now to FIG. **1**D, a network environment for delivering and/or operating a computing environment on a client **102** is depicted. In some embodiments, a server **106** includes an application delivery system **190** for delivering a computing environment or an application and/or data file to one or more clients **102**. In brief overview, a client **10** is in communication with a server **106** via network **104**, **104'** and appliance **200**. For example, the client **102** may reside in a remote office of a company, e.g., a branch office, and the server **106** may reside at a corporate data center. The client **102** comprises a client agent **120**, and a computing environment **15**. The computing environment **15** may execute or operate an application that accesses, processes or uses a data file. The computing environment **15**, application and/or data file may be delivered via the appliance **200** and/or the server **106**.

In some embodiments, the appliance **200** accelerates delivery of a computing environment **15**, or any portion thereof, to a client **102**. In one embodiment, the appliance **200** accelerates the delivery of the computing environment **15** by the application delivery system **190**. For example, the embodiments described herein may be used to accelerate delivery of a streaming application and data file processable by the application from a central corporate data center to a remote user location, such as a branch office of the company. In another embodiment, the appliance **200** accelerates transport layer traffic between a client **102** and a server **106**. The appliance **200** may provide acceleration techniques for accelerating any transport layer payload from a server **106** to a client **102**, such as: 1) transport layer connection pooling, 2) transport layer connection multiplexing, 3) transport control protocol buffering, 4) compression and 5) caching. In some embodiments, the appliance **200** provides load balancing of servers **106** in responding to requests from clients **102**. In other embodiments, the appliance **200** acts as a proxy or access server to provide access to the one or more servers **106**. In another embodiment, the appliance **200** provides a secure virtual private network connection from a first network **104** of the client **102** to the second network **104'** of the server **106**, such as an SSL VPN connection. It yet other embodiments, the appliance **200** provides application firewall security, control and management of the connection and communications between a client **102** and a server **106**.

In some embodiments, the application delivery management system **190** provides application delivery techniques to deliver a computing environment to a desktop of a user, remote or otherwise, based on a plurality of execution methods and based on any authentication and authorization policies applied via a policy engine **195**. With these techniques, a remote user may obtain a computing environment and access to server stored applications and data files from any network connected device **100**. In one embodiment, the application delivery system **190** may reside or execute on a server **106**. In another embodiment, the application delivery system **190** may reside or execute on a plurality of servers **106***a*-**106***n*. In some embodiments, the application delivery system **190** may execute in a server farm **38**. In one embodiment, the server **106** executing the application delivery system **190** may also store or provide the application and data file. In another embodiment, a first set of one or more servers **106** may execute the application delivery system **190**, and a different server **106***n* may store or provide the application and data file. In some embodiments, each of the application delivery system **190**, the application, and data file may reside or be located

on different servers. In yet another embodiment, any portion of the application delivery system **190** may reside, execute or be stored on or distributed to the appliance **200**, or a plurality of appliances.

The client **102** may include a computing environment **15** for executing an application that uses or processes a data file. The client **102** via networks **104**, **104'** and appliance **200** may request an application and data file from the server **106**. In one embodiment, the appliance **200** may forward a request from the client **102** to the server **106**. For example, the client **102** may not have the application and data file stored or accessible locally. In response to the request, the application delivery system **190** and/or server **106** may deliver the application and data file to the client **102**. For example, in one embodiment, the server **106** may transmit the application as an application stream to operate in computing environment **15** on client **102**.

In some embodiments, the application delivery system **190** comprises any portion of the Citrix Access Suite™ by Citrix Systems, Inc., such as the MetaFrame or Citrix Presentation Server™ and/or any of the Microsoft® Windows Terminal Services manufactured by the Microsoft Corporation. In one embodiment, the application delivery system **190** may deliver one or more applications to clients **102** or users via a remote-display protocol or otherwise via remote-based or server-based computing. In another embodiment, the application delivery system **190** may deliver one or more applications to clients or users via steaming of the application.

In one embodiment, the application delivery system **190** includes a policy engine **195** for controlling and managing the access to, selection of application execution methods and the delivery of applications. In some embodiments, the policy engine **195** determines the one or more applications a user or client **102** may access. In another embodiment, the policy engine **195** determines how the application should be delivered to the user or client **102**, e.g., the method of execution. In some embodiments, the application delivery system **190** provides a plurality of delivery techniques from which to select a method of application execution, such as a server-based computing, streaming or delivering the application locally to the client **120** for local execution.

In one embodiment, a client **102** requests execution of an application program and the application delivery system **190** comprising a server **106** selects a method of executing the application program. In some embodiments, the server **106** receives credentials from the client **102**. In another embodiment, the server **106** receives a request for an enumeration of available applications from the client **102**. In one embodiment, in response to the request or receipt of credentials, the application delivery system **190** enumerates a plurality of application programs available to the client **102**. The application delivery system **190** receives a request to execute an enumerated application. The application delivery system **190** selects one of a predetermined number of methods for executing the enumerated application, for example, responsive to a policy of a policy engine. The application delivery system **190** may select a method of execution of the application enabling the client **102** to receive application-output data generated by execution of the application program on a server **106**. The application delivery system **190** may select a method of execution of the application enabling the local machine **10** to execute the application program locally after retrieving a plurality of application files comprising the application. In yet another embodiment, the application delivery system **190** may select a method of execution of the application to stream the application via the network **104** to the client **102**.

A client **102** may execute, operate or otherwise provide an application, which can be any type and/or form of software, program, or executable instructions such as any type and/or form of web browser, web-based client, client-server application, a thin-client computing client, an ActiveX control, or a Java applet, or any other type and/or form of executable instructions capable of executing on client **102**. In some embodiments, the application may be a server-based or a remote-based application executed on behalf of the client **102** on a server **106**. In one embodiments the server **106** may display output to the client **102** using any thin-client or remote-display protocol, such as the Independent Computing Architecture (ICA) protocol manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. or the Remote Desktop Protocol (RDP) manufactured by the Microsoft Corporation of Redmond, Wash. The application can use any type of protocol and it can be, for example, an HTTP client, an FTP client, an Oscar client, or a Telnet client. In other embodiments, the application comprises any type of software related to VoIP communications, such as a soft IP telephone. In further embodiments, the application comprises any application related to real-time data communications, such as applications for streaming video and/or audio.

In some embodiments, the server **106** or a server farm **38** may be running one or more applications, such as an application providing a thin-client computing or remote display presentation application. In one embodiment, the server **106** or server farm **38** executes as an application, any portion of the Citrix Access Suite™ by Citrix Systems, Inc., such as the MetaFrame or Citrix Presentation Server™, and/or any of the Microsoft® Windows Terminal Services manufactured by the Microsoft Corporation. In one embodiment, the application is an ICA client, developed by Citrix Systems, Inc. of Fort Lauderdale, Fla. In other embodiments, the application includes a Remote Desktop (RDP) client, developed by Microsoft Corporation of Redmond, Wash. Also, the server **106** may run an application, which for example, may be an application server providing email services such as Microsoft Exchange manufactured by the Microsoft Corporation of Redmond, Wash., a web or Internet server, or a desktop sharing server, or a collaboration server. In some embodiments, any of the applications may comprise any type of hosted service or products, such as GoToMeeting™ provided by Citrix Online Division, Inc. of Santa Barbara, Calif., WebEx™ provided by WebEx, Inc. of Santa Clara, Calif., or Microsoft Office Live Meeting provided by Microsoft Corporation of Redmond, Wash.

Still referring to FIG. **1**D, an embodiment of the network environment may include a monitoring server **106**A. The monitoring server **106**A may include any type and form performance monitoring service **198**. The performance monitoring service **198** may include monitoring, measurement and/or management software and/or hardware, including data collection, aggregation, analysis, management and reporting. In one embodiment, the performance monitoring service **198** includes one or more monitoring agents **197**. The monitoring agent **197** includes any software, hardware or combination thereof for performing monitoring, measurement and data collection activities on a device, such as a client **102**, server **106** or an appliance **200**, **205**. In some embodiments, the monitoring agent **197** includes any type and form of script, such as Visual Basic script, or Javascript. In one embodiment, the monitoring agent **197** executes transparently to any application and/or user of the device. In some embodiments, the monitoring agent **197** is installed and operated unobtrusively to the application or client. In yet another embodiment, the

monitoring agent **197** is installed and operated without any instrumentation for the application or device.

In some embodiments, the monitoring agent **197** monitors, measures and collects data on a predetermined frequency. In other embodiments, the monitoring agent **197** monitors, measures and collects data based upon detection of any type and form of event. For example, the monitoring agent **197** may collect data upon detection of a request for a web page or receipt of an HTTP response. In another example, the monitoring agent **197** may collect data upon detection of any user input events, such as a mouse click. The monitoring agent **197** may report or provide any monitored, measured or collected data to the monitoring service **198**. In one embodiment, the monitoring agent **197** transmits information to the monitoring service **198** according to a schedule or a predetermined frequency. In another embodiment, the monitoring agent **197** transmits information to the monitoring service **198** upon detection of an event.

In some embodiments, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of any network resource or network infrastructure element, such as a client, server, server farm, appliance **200**, appliance **205**, or network connection. In one embodiment, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of any transport layer connection, such as a TCP or UDP connection. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures network latency. In yet one embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures bandwidth utilization.

In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures end-user response times. In some embodiments, the monitoring service **198** performs monitoring and performance measurement of an application. In another embodiment, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of any session or connection to the application. In one embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a browser. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of HTTP based transactions. In some embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a Voice over IP (VoIP) application or session. In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a remote display protocol application, such as an ICA client or RDP client. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of any type and form of streaming media. In still a further embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a hosted application or a Software-As-A-Service (SaaS) delivery model.

In some embodiments, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of one or more transactions, requests or responses related to application. In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures any portion of an application layer stack, such as any .NET or J2EE calls. In one embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures database or SQL transactions. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures any method, function or application programming interface (API) call.

In one embodiment, the monitoring service **198** and/or monitoring agent **197** performs monitoring and performance measurement of a delivery of application and/or data from a server to a client via one or more appliances, such as appliance **200** and/or appliance **205**. In some embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of delivery of a virtualized application. In other embodiments, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of delivery of a streaming application. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of delivery of a desktop application to a client and/or the execution of the desktop application on the client. In another embodiment, the monitoring service **198** and/or monitoring agent **197** monitors and measures performance of a client/server application.

In one embodiment, the monitoring service **198** and/or monitoring agent **197** is designed and constructed to provide application performance management for the application delivery system **190**. For example, the monitoring service **198** and/or monitoring agent **197** may monitor, measure and manage the performance of the delivery of applications via the Citrix Presentation Server. In this example, the monitoring service **198** and/or monitoring agent **197** monitors individual ICA sessions. The monitoring service **198** and/or monitoring agent **197** may measure the total and per session system resource usage, as well as application and networking performance. The monitoring service **198** and/or monitoring agent **197** may identify the active servers for a given user and/or user session. In some embodiments, the monitoring service **198** and/or monitoring agent **197** monitors back-end connections between the application delivery system **190** and an application and/or database server. The monitoring service **198** and/or monitoring agent **197** may measure network latency, delay and volume per user-session or ICA session.

In some embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors memory usage for the application delivery system **190**, such as total memory usage, per user session and/or per process. In other embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors CPU usage the application delivery system **190**, such as total CPU usage, per user session and/or per process. In another embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors the time required to log-in to an application, a server, or the application delivery system, such as Citrix Presentation Server. In one embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors the duration a user is logged into an application, a server, or the application delivery system **190**. In some embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors active and inactive session counts for an application, server or application delivery system session. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors user session latency.

In yet further embodiments, the monitoring service **198** and/or monitoring agent **197** measures and monitors measures and monitors any type and form of server metrics. In one embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors metrics related to system memory, CPU usage, and disk storage. In another embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors metrics related to page faults, such as page faults per second. In other embodiments, the

monitoring service **198** and/or monitoring agent **197** measures and monitors round-trip time metrics. In yet another embodiment, the monitoring service **198** and/or monitoring agent **197** measures and monitors metrics related to application crashes, errors and/or hangs.

In some embodiments, the monitoring service **198** and monitoring agent **198** includes any of the product embodiments referred to as EdgeSight manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla. In another embodiment, the performance monitoring service **198** and/or monitoring agent **198** includes any portion of the product embodiments referred to as the TrueView product suite manufactured by the Symphoniq Corporation of Palo Alto, Calif.

In one embodiment, the performance monitoring service **198** and/or monitoring agent **198** includes any portion of the product embodiments referred to as the TeaLeaf CX product suite manufactured by the TeaLeaf Technology Inc. of San Francisco, Calif. In other embodiments, the performance monitoring service **198** and/or monitoring agent **198** includes any portion of the business service management products, such as the BMC Performance Manager and Patrol products, manufactured by BMC Software, Inc. of Houston, Tex.

The client **102**, server **106**, and appliance **200** may be deployed as and/or executed on any type and form of computing device, such as a computer, network device or appliance capable of communicating on any type and form of network and performing the operations described herein. FIGS. **1**E and **1**F depict block diagrams of a computing device **100** useful for practicing an embodiment of the client **102**, server **106** or appliance **200**. As shown in FIGS. **1**E and **1**F, each computing device **100** includes a central processing unit **101**, and a main memory unit **122**. As shown in FIG. **1**E, a computing device **100** may include a visual display device **124**, a keyboard **126** and/or a pointing device **127**, such as a mouse. Each computing device **100** may also include additional optional elements, such as one or more input/output devices **130***a*-**130***b* (generally referred to using reference numeral **130**), and a cache memory **140** in communication with the central processing unit **101**.

The central processing unit **101** is any logic circuitry that responds to and processes instructions fetched from the main memory unit **122**. In many embodiments, the central processing unit is provided by a microprocessor unit, such as: those manufactured by Intel Corporation of Mountain View, Calif.; those manufactured by Motorola Corporation of Schaumburg, Ill.; those manufactured by Transmeta Corporation of Santa Clara, Calif.; the RS/6000 processor, those manufactured by International Business Machines of White Plains, N.Y.; or those manufactured by Advanced Micro Devices of Sunnyvale, Calif. The computing device **100** may be based on any of these processors, or any other processor capable of operating as described herein.

Main memory unit **122** may be one or more memory chips capable of storing data and allowing any storage location to be directly accessed by the microprocessor **101**, such as Static random access memory (SRAM), Burst SRAM or Synch-Burst SRAM (BSRAM), Dynamic random access memory (DRAM), Fast Page Mode DRAM (FPM DRAM), Enhanced DRAM (EDRAM), Extended Data Output RAM (EDO RAM), Extended Data Output DRAM (EDO DRAM), Burst Extended Data Output DRAM (BEDO DRAM), Enhanced DRAM (EDRAM), synchronous DRAM (SDRAM), JEDEC SRAM, PC **100** SDRAM, Double Data Rate SDRAM (DDR SDRAM), Enhanced SDRAM (ESDRAM), SyncLink DRAM (SLDRAM), Direct Rambus DRAM (DRDRAM), or Ferroelectric RAM (FRAM). The main memory **122** may be based on any of the above described memory chips, or any other available memory chips capable of operating as described herein. In the embodiment shown in FIG. **1**E, the processor **101** communicates with main memory **122** via a system bus **150** (described in more detail below). FIG. **1**E depicts an embodiment of a computing device **100** in which the processor communicates directly with main memory **122** via a memory port **103**. For example, in FIG. **1**F the main memory **122** may be DRDRAM.

FIG. **1**F depicts an embodiment in which the main processor **101** communicates directly with cache memory **140** via a secondary bus, sometimes referred to as a backside bus. In other embodiments, the main processor **101** communicates with cache memory **140** using the system bus **150**. Cache memory **140** typically has a faster response time than main memory **122** and is typically provided by SRAM, BSRAM, or EDRAM. In the embodiment shown in FIG. **1**E, the processor **101** communicates with various J/O devices **130** via a local system bus **150**. Various busses may be used to connect the central processing unit **101** to any of the I/O devices **130**, including a VESA VL bus, an ISA bus, an EISA bus, a MicroChannel Architecture (MCA) bus, a PCI bus, a PCI-X bus, a PCI-Express bus, or a NuBus. For embodiments in which the I/O device is a video display **124**, the processor **101** may use an Advanced Graphics Port (AGP) to communicate with the display **124**. FIG. **1**F depicts an embodiment of a computer **100** in which the main processor **101** communicates directly with I/O device **130** via HyperTransport, Rapid I/O, or InfiniBand. FIG. **1**F also depicts an embodiment in which local busses and direct communication are mixed: the processor **101** communicates with I/O device **130** using a local interconnect bus while communicating with I/O device **130** directly.

The computing device **100** may support any suitable installation device **116**, such as a floppy disk drive for receiving floppy disks such as 3.5-inch, 5.25-inch disks or ZIP disks, a CD-ROM drive, a CD-R/RW drive, a DVD-ROM drive, tape drives of various formats, USB device, hard-drive or any other device suitable for installing software and programs such as any client agent **120**, or portion thereof. The computing device **100** may further comprise a storage device **128**, such as one or more hard disk drives or redundant arrays of independent disks, for storing an operating system and other related software, and for storing application software programs such as any program related to the client agent **120**. Optionally, any of the installation devices **116** could also be used as the storage device **128**. Additionally, the operating system and the software can be run from a bootable medium, for example, a bootable CD, such as KNOPPIX®, a bootable CD for GNU/Linux that is available as a GNU/Linux distribution from knoppix.net.

Furthermore, the computing device **100** may include a network interface **118** to interface to a Local Area Network (LAN), Wide Area Network (WAN) or the Internet through a variety of connections including, but not limited to, standard telephone lines, LAN or WAN links (e.g., 802.11, T1, T3, 56 kb, X.25), broadband connections (e.g. ISDN, Frame Relay, ATM), wireless connections, or some combination of any or all of the above. The network interface **118** may comprise a built-in network adapter, network interface card, PCMCIA network card, card bus network adapter, wireless network adapter, USB network adapter, modem or any other device suitable for interfacing the computing device **100** to any type of network capable of communication and performing the operations described herein.

A wide variety of I/O devices **130***a*-**130***n* may be present in the computing device **100**. Input devices include keyboards, mice, trackpads, trackballs, microphones, and drawing tab-

lets. Output devices include video displays, speakers, inkjet printers, laser printers, and dye-sublimation printers. The I/O devices **130** may be controlled by an I/O controller **123** as shown in FIG. **1**E. The I/O controller may control one or more I/O devices such as a keyboard **126** and a pointing device **127**, e.g., a mouse or optical pen. Furthermore, an I/O device may also provide storage **128** and/or an installation medium **116** for the computing device **100**. In still other embodiments, the computing device **100** may provide USB connections to receive handheld USB storage devices such as the USB Flash Drive line of devices manufactured by Twintech Industry, Inc. of Los Alamitos, Calif.

In some embodiments, the computing device **100** may comprise or be connected to multiple display devices **124***a*-**124***n*, which each may be of the same or different type and/or form. As such, any of the I/O devices **130***a*-**130***n* and/or the I/O controller **123** may comprise any type and/or form of suitable hardware, software, or combination of hardware and software to support, enable or provide for the connection and use of multiple display devices **124***a*-**124***n* by the computing device **100**. For example, the computing device **100** may include any type and/or form of video adapter, video card, driver, and/or library to interface, communicate, connect or otherwise use the display devices **124***a*-**124***n*. In one embodiment, a video adapter may comprise multiple connectors to interface to multiple display devices **124***a*-**124***n*. In other embodiments, the computing device **100** may include multiple video adapters, with each video adapter connected to one or more of the display devices **124***a*-**124***n*. In some embodiments, any portion of the operating system of the computing device **100** may be configured for using multiple displays **124***a*-**124***n*. In other embodiments, one or more of the display devices **124***a*-**124***n* may be provided by one or more other computing devices, such as computing devices **100***a* and **100***b* connected to the computing device **100**, for example, via a network. These embodiments may include any type of software designed and constructed to use another computer's display device as a second display device **124***a* for the computing device **100**. One ordinarily skilled in the art will recognize and appreciate the various ways and embodiments that a computing device **100** may be configured to have multiple display devices **124***a*-**124***n*.

In further embodiments, an I/O device **130** may be a bridge **170** between the system bus **150** and an external communication bus, such as a USB bus, an Apple Desktop Bus, an RS-232 serial connection, a SCSI bus, a FireWire bus, a FireWire **800** bus, an Ethernet bus, an AppleTalk bus, a Gigabit Ethernet bus, an Asynchronous Transfer Mode bus, a HIPPI bus, a Super HIPPI bus, a SerialPlus bus, a SCI/LAMP bus, a FibreChannel bus, or a Serial Attached small computer system interface bus.

A computing device **100** of the sort depicted in FIGS. **1**E and **1**F typically operate under the control of operating systems, which control scheduling of tasks and access to system resources. The computing device **100** can be running any operating system such as any of the versions of the Microsoft® Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the Mac OS® for Macintosh computers, any embedded operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices, or any other operating system capable of running on the computing device and performing the operations described herein. Typical operating systems include: WINDOWS 3.x, WINDOWS 95, WINDOWS 98, WINDOWS 2000, WINDOWS NT 3.51, WINDOWS NT 4.0, WINDOWS CE, and WINDOWS XP, all of which are manufactured by Microsoft Corporation of Redmond, Wash.; MacOS, manufactured by Apple Computer of Cupertino, Calif.; OS/2, manufactured by International Business Machines of Armonk, N.Y.; and Linux, a freely-available operating system distributed by Caldera Corp. of Salt Lake City, Utah, or any type and/or form of a Unix operating system, among others.

In other embodiments, the computing device **100** may have different processors, operating systems, and input devices consistent with the device. For example, in one embodiment the computer **100** is a Treo 180, 270, 1060, 600 or 650 smart phone manufactured by Palm, Inc. In this embodiment, the Treo smart phone is operated under the control of the PalmOS operating system and includes a stylus input device as well as a five-way navigator device. Moreover, the computing device **100** can be any workstation, desktop computer, laptop or notebook computer, server, handheld computer, mobile telephone, any other computer, or other form of computing or telecommunications device that is capable of communication and that has sufficient processor power and memory capacity to perform the operations described herein.

B. Appliance Architecture

FIG. **2**A illustrates an example embodiment of the appliance **200**. The architecture of the appliance **200** in FIG. **2**A is provided by way of illustration only and is not intended to be limiting. As shown in FIG. **2**, appliance **200** comprises a hardware layer **206** and a software layer divided into a user space **202** and a kernel space **204**.

Hardware layer **206** provides the hardware elements upon which programs and services within kernel space **204** and user space **202** are executed. Hardware layer **206** also provides the structures and elements which allow programs and services within kernel space **204** and user space **202** to communicate data both internally and externally with respect to appliance **200**. As shown in FIG. **2**, the hardware layer **206** includes a processing unit **262** for executing software programs and services, a memory **264** for storing software and data, network ports **266** for transmitting and receiving data over a network, and an encryption processor **260** for performing functions related to Secure Sockets Layer processing of data transmitted and received over the network. In some embodiments, the central processing unit **262** may perform the functions of the encryption processor **260** in a single processor. Additionally, the hardware layer **206** may comprise multiple processors for each of the processing unit **262** and the encryption processor **260**. The processor **262** may include any of the processors **101** described above in connection with FIGS. **1**E and **1**F. In some embodiments, the central processing unit **262** may perform the functions of the encryption processor **260** in a single processor. Additionally, the hardware layer **206** may comprise multiple processors for each of the processing unit **262** and the encryption processor **260**. For example, in one embodiment, the appliance **200** comprises a first processor **262** and a second processor **262'**. In other embodiments, the processor **262** or **262'** comprises a multi-core processor.

Although the hardware layer **206** of appliance **200** is generally illustrated with an encryption processor **260**, processor **260** may be a processor for performing functions related to any encryption protocol, such as the Secure Socket Layer (SSL) or Transport Layer Security (TLS) protocol. In some embodiments, the processor **260** may be a general purpose processor (GPP), and in further embodiments, may be have executable instructions for performing processing of any security related protocol.

Although the hardware layer **206** of appliance **200** is illustrated with certain elements in FIG. **2**, the hardware portions

or components of appliance **200** may comprise any type and form of elements, hardware or software, of a computing device, such as the computing device **100** illustrated and discussed herein in conjunction with FIGS. **1**E and **1**F. In some embodiments, the appliance **200** may comprise a server, gateway, router, switch, bridge or other type of computing or network device, and have any hardware and/or software elements associated therewith.

The operating system of appliance **200** allocates, manages, or otherwise segregates the available system memory into kernel space **204** and user space **204**. In example software architecture **200**, the operating system may be any type and/or form of UNIX operating system although the invention is not so limited. As such, the appliance **200** can be running any operating system such as any of the versions of the Microsoft® Windows operating systems, the different releases of the Unix and Linux operating systems, any version of the Mac OS® for Macintosh computers, any embedded operating system, any network operating system, any real-time operating system, any open source operating system, any proprietary operating system, any operating systems for mobile computing devices or network devices, or any other operating system capable of running on the appliance **200** and performing the operations described herein.

The kernel space **204** is reserved for running the kernel **230**, including any device drivers, kernel extensions or other kernel related software. As known to those skilled in the art, the kernel **230** is the core of the operating system, and provides access, control, and management of resources and hardware-related elements of the application **104**. In accordance with an embodiment of the appliance **200**, the kernel space **204** also includes a number of network services or processes working in conjunction with a cache manager **232**, sometimes also referred to as the integrated cache, the benefits of which are described in detail further herein. Additionally, the embodiment of the kernel **230** will depend on the embodiment of the operating system installed, configured, or otherwise used by the device **200**.

In one embodiment, the device **200** comprises one network stack **267**, such as a TCP/IP based stack, for communicating with the client **102** and/or the server **106**. In one embodiment, the network stack **267** is used to communicate with a first network, such as network **108**, and a second network **110**. In some embodiments, the device **200** terminates a first transport layer connection, such as a TCP connection of a client **102**, and establishes a second transport layer connection to a server **106** for use by the client **102**, e.g., the second transport layer connection is terminated at the appliance **200** and the server **106**. The first and second transport layer connections may be established via a single network stack **267**. In other embodiments, the device **200** may comprise multiple network stacks, for example **267** and **267'**, and the first transport layer connection may be established or terminated at one network stack **267**, and the second transport layer connection on the second network stack **267'**. For example, one network stack may be for receiving and transmitting network packet on a first network, and another network stack for receiving and transmitting network packets on a second network. In one embodiment, the network stack **267** comprises a buffer **243** for queuing one or more network packets for transmission by the appliance **200**.

As shown in FIG. **2**, the kernel space **204** includes the cache manager **232**, a high-speed layer **2-7** integrated packet engine **240**, an encryption engine **234**, a policy engine **236** and multi-protocol compression logic **238**. Running these components or processes **232**, **240**, **234**, **236** and **238** in kernel space **204** or kernel mode instead of the user space **202** improves the performance of each of these components, alone and in combination. Kernel operation means that these components or processes **232**, **240**, **234**, **236** and **238** run in the core address space of the operating system of the device **200**. For example, running the encryption engine **234** in kernel mode improves encryption performance by moving encryption and decryption operations to the kernel, thereby reducing the number of transitions between the memory space or a kernel thread in kernel mode and the memory space or a thread in user mode. For example, data obtained in kernel mode may not need to be passed or copied to a process or thread running in user mode, such as from a kernel level data structure to a user level data structure. In another aspect, the number of context switches between kernel mode and user mode are also reduced. Additionally, synchronization of and communications between any of the components or processes **232**, **240**, **235**, **236** and **238** can be performed more efficiently in the kernel space **204**.

In some embodiments, any portion of the components **232**, **240**, **234**, **236** and **238** may run or operate in the kernel space **204**, while other portions of these components **232**, **240**, **234**, **236** and **238** may run or operate in user space **202**. In one embodiment, the appliance **200** uses a kernel-level data structure providing access to any portion of one or more network packets, for example, a network packet comprising a request from a client **102** or a response from a server **106**. In some embodiments, the kernel-level data structure may be obtained by the packet engine **240** via a transport layer driver interface or filter to the network stack **267**. The kernel-level data structure may comprise any interface and/or data accessible via the kernel space **204** related to the network stack **267**, network traffic or packets received or transmitted by the network stack **267**. In other embodiments, the kernel-level data structure may be used by any of the components or processes **232**, **240**, **234**, **236** and **238** to perform the desired operation of the component or process. In one embodiment, a component **232**, **240**, **234**, **236** and **238** is running in kernel mode **204** when using the kernel-level data structure, while in another embodiment, the component **232**, **240**, **234**, **236** and **238** is running in user mode when using the kernel-level data structure. In some embodiments, the kernel-level data structure may be copied or passed to a second kernel-level data structure, or any desired user-level data structure.

The cache manager **232** may comprise software, hardware or any combination of software and hardware to provide cache access, control and management of any type and form of content, such as objects or dynamically generated objects served by the originating servers **106**. The data, objects or content processed and stored by the cache manager **232** may comprise data in any format, such as a markup language, or communicated via any protocol. In some embodiments, the cache manager **232** duplicates original data stored elsewhere or data previously computed, generated or transmitted, in which the original data may require longer access time to fetch, compute or otherwise obtain relative to reading a cache memory element. Once the data is stored in the cache memory element, future use can be made by accessing the cached copy rather than refetching or recomputing the original data, thereby reducing the access time. In some embodiments, the cache memory element may comprise a data object in memory **264** of device **200**. In other embodiments, the cache memory element may comprise memory having a faster access time than memory **264**. In another embodiment, the cache memory element may comprise any type and form of storage element of the device **200**, such as a portion of a hard disk. In some embodiments, the processing unit **262** may provide cache memory for use by the cache manager **232**. In

yet further embodiments, the cache manager **232** may use any portion and combination of memory, storage, or the processing unit for caching data, objects, and other content.

Furthermore, the cache manager **232** includes any logic, functions, rules, or operations to perform any embodiments of the techniques of the appliance **200** described herein. For example, the cache manager **232** includes logic or functionality to invalidate objects based on the expiration of an invalidation time period or upon receipt of an invalidation command from a client **102** or server **106**. In some embodiments, the cache manager **232** may operate as a program, service, process or task executing in the kernel space **204**, and in other embodiments, in the user space **202**. In one embodiment, a first portion of the cache manager **232** executes in the user space **202** while a second portion executes in the kernel space **204**. In some embodiments, the cache manager **232** can comprise any type of general purpose processor (GPP), or any other type of integrated circuit, such as a Field Programmable Gate Array (FPGA), Programmable Logic Device (PLD), or Application Specific Integrated Circuit (ASIC).

The policy engine **236** may include, for example, an intelligent statistical engine or other programmable application(s). In one embodiment, the policy engine **236** provides a configuration mechanism to allow a user to identify, specify, define or configure a caching policy. Policy engine **236**, in some embodiments, also has access to memory to support data structures such as lookup tables or hash tables to enable user-selected caching policy decisions. In other embodiments, the policy engine **236** may comprise any logic, rules, functions or operations to determine and provide access, control and management of objects, data or content being cached by the appliance **200** in addition to access, control and management of security, network traffic, network access, compression or any other function or operation performed by the appliance **200**. Further examples of specific caching policies are further described herein.

In some embodiments, the policy engine **236** may provide a configuration mechanism to allow a user to identify, specify, define or configure policies directing behavior of any other components or functionality of an appliance, including without limitation the components described in FIG. **2**B such as vServers **275**, VPN functions **280**, Intranet IP functions **282**, switching functions **284**, DNS functions **286**, acceleration functions **288**, application firewall functions **290**, and monitoring agents **197**. In other embodiments, the policy engine **236** may check, evaluate, implement, or otherwise act in response to any configured policies, and may also direct the operation of one or more appliance functions in response to a policy.

The encryption engine **234** comprises any logic, business rules, functions or operations for handling the processing of any security related protocol, such as SSL or TLS, or any function related thereto. For example, the encryption engine **234** encrypts and decrypts network packets, or any portion thereof, communicated via the appliance **200**. The encryption engine **234** may also setup or establish SSL or TLS connections on behalf of the client **102***a*-**102***n*, server **106***a*-**106***n*, or appliance **200**. As such, the encryption engine **234** provides offloading and acceleration of SSL processing. In one embodiment, the encryption engine **234** uses a tunneling protocol to provide a virtual private network between a client **102***a*-**102***n* and a server **106***a*-**106***n*. In some embodiments, the encryption engine **234** is in communication with the Encryption processor **260**. In other embodiments, the encryption engine **234** comprises executable instructions running on the Encryption processor **260**.

The multi-protocol compression engine **238** comprises any logic, business rules, function or operations for compressing one or more protocols of a network packet, such as any of the protocols used by the network stack **267** of the device **200**. In one embodiment, multi-protocol compression engine **238** compresses bi-directionally between clients **102***a*-**102***n* and servers **106***a*-**106***n* any TCP/IP based protocol, including Messaging Application Programming Interface (MAPI) (email), File Transfer Protocol (FTP), HyperText Transfer Protocol (HTTP), Common Internet File System (CIFS) protocol (file transfer), Independent Computing Architecture (ICA) protocol, Remote Desktop Protocol (RDP), Wireless Application Protocol (WAP), Mobile IP protocol, and Voice Over IP (VoIP) protocol. In other embodiments, multi-protocol compression engine **238** provides compression of Hypertext Markup Language (HTML) based protocols and in some embodiments, provides compression of any markup languages, such as the Extensible Markup Language (XML). In one embodiment, the multi-protocol compression engine **238** provides compression of any high-performance protocol, such as any protocol designed for appliance **200** to appliance **200** communications. In another embodiment, the multi-protocol compression engine **238** compresses any payload of or any communication using a modified transport control protocol, such as Transaction TCP (T/TCP), TCP with selection acknowledgements (TCP-SACK), TCP with large windows (TCP-LW), a congestion prediction protocol such as the TCP-Vegas protocol, and a TCP spoofing protocol.

As such, the multi-protocol compression engine **238** accelerates performance for users accessing applications via desktop clients, e.g., Microsoft Outlook and non-Web thin clients, such as any client launched by popular enterprise applications like Oracle, SAP and Siebel, and even mobile clients, such as the Pocket PC. In some embodiments, the multi-protocol compression engine **238** by executing in the kernel mode **204** and integrating with packet processing engine **240** accessing the network stack **267** is able to compress any of the protocols carried by the TCP/IP protocol, such as any application layer protocol.

High speed layer **2**-**7** integrated packet engine **240**, also generally referred to as a packet processing engine or packet engine, is responsible for managing the kernel-level processing of packets received and transmitted by appliance **200** via network ports **266**. The high speed layer **2**-**7** integrated packet engine **240** may comprise a buffer for queuing one or more network packets during processing, such as for receipt of a network packet or transmission of a network packer. Additionally, the high speed layer **2**-**7** integrated packet engine **240** is in communication with one or more network stacks **267** to send and receive network packets via network ports **266**. The high speed layer **2**-**7** integrated packet engine **240** works in conjunction with encryption engine **234**, cache manager **232**, policy engine **236** and multi-protocol compression logic **238**. In particular, encryption engine **234** is configured to perform SSL processing of packets, policy engine **236** is configured to perform functions related to traffic management such as request-level content switching and request-level cache redirection, and multi-protocol compression logic **238** is configured to perform functions related to compression and decompression of data.

The high speed layer **2**-**7** integrated packet engine **240** includes a packet processing timer **242**. In one embodiment, the packet processing timer **242** provides one or more time intervals to trigger the processing of incoming, i.e., received, or outgoing, i.e., transmitted, network packets. In some embodiments, the high speed layer **2**-**7** integrated packet engine **240** processes network packets responsive to the timer

242. The packet processing timer 242 provides any type and form of signal to the packet engine 240 to notify, trigger, or communicate a time related event, interval or occurrence. In many embodiments, the packet processing timer 242 operates in the order of milliseconds, such as for example 100 ms, 50 ms or 25 ms. For example, in some embodiments, the packet processing timer 242 provides time intervals or otherwise causes a network packet to be processed by the high speed layer 2-7 integrated packet engine 240 at a 10 ms time interval, while in other embodiments, at a 5 ms time interval, and still yet in further embodiments, as short as a 3, 2, or 1 ms time interval. The high speed layer 2-7 integrated packet engine 240 may be interfaced, integrated or in communication with the encryption engine 234, cache manager 232, policy engine 236 and multi-protocol compression engine 238 during operation. As such, any of the logic, functions, or operations of the encryption engine 234, cache manager 232, policy engine 236 and multi-protocol compression logic 238 may be performed responsive to the packet processing timer 242 and/or the packet engine 240. Therefore, any of the logic, functions, or operations of the encryption engine 234, cache manager 232, policy engine 236 and multi-protocol compression logic 238 may be performed at the granularity of time intervals provided via the packet processing timer 242, for example, at a time interval of less than or equal to 10 ms. For example, in one embodiment, the cache manager 232 may perform invalidation of any cached objects responsive to the high speed layer 2-7 integrated packet engine 240 and/or the packet processing timer 242. In another embodiment, the expiry or invalidation time of a cached object can be set to the same order of granularity as the time interval of the packet processing timer 242, such as at every 10 ms.

In contrast to kernel space 204, user space 202 is the memory area or portion of the operating system used by user mode applications or programs otherwise running in user mode. A user mode application may not access kernel space 204 directly and uses service calls in order to access kernel services. As shown in FIG. 2, user space 202 of appliance 200 includes a graphical user interface (GUI) 210, a command line interface (CLI) 212, shell services 214, health monitoring program 216, and daemon services 218. GUI 210 and CLI 212 provide a means by which a system administrator or other user can interact with and control the operation of appliance 200, such as via the operating system of the appliance 200 and either is user space 202 or kernel space 204. The GUI 210 may be any type and form of graphical user interface and may be presented via text, graphical or otherwise, by any type of program or application, such as a browser. The CLI 212 may be any type and form of command line or text-based interface, such as a command line provided by the operating system. For example, the CLI 212 may comprise a shell, which is a tool to enable users to interact with the operating system. In some embodiments, the CLI 212 may be provided via a bash, csh, tcsh, or ksh type shell. The shell services 214 comprises the programs, services, tasks, processes or executable instructions to support interaction with the appliance 200 or operating system by a user via the GUI 210 and/or CLI 212.

Health monitoring program 216 is used to monitor, check, report and ensure that network systems are functioning properly and that users are receiving requested content over a network. Health monitoring program 216 comprises one or more programs, services, tasks, processes or executable instructions to provide logic, rules, functions or operations for monitoring any activity of the appliance 200. In some embodiments, the health monitoring program 216 intercepts and inspects any network traffic passed via the appliance 200. In other embodiments, the health monitoring program 216 interfaces by any suitable means and/or mechanisms with one or more of the following: the encryption engine 234, cache manager 232, policy engine 236, multi-protocol compression logic 238, packet engine 240, daemon services 218, and shell services 214. As such, the health monitoring program 216 may call any application programming interface (API) to determine a state, status, or health of any portion of the appliance 200. For example, the health monitoring program 216 may ping or send a status inquiry on a periodic basis to check if a program, process, service or task is active and currently running. In another example, the health monitoring program 216 may check any status, error or history logs provided by any program, process, service or task to determine any condition, status or error with any portion of the appliance 200.

Daemon services 218 are programs that run continuously or in the background and handle periodic service requests received by appliance 200. In some embodiments, a daemon service may forward the requests to other programs or processes, such as another daemon service 218 as appropriate. As known to those skilled in the art, a daemon service 218 may run unattended to perform continuous or periodic system wide functions, such as network control, or to perform any desired task. In some embodiments, one or more daemon services 218 run in the user space 202, while in other embodiments, one or more daemon services 218 run in the kernel space.

Referring now to FIG. 2B, another embodiment of the appliance 200 is depicted. In brief overview, the appliance 200 provides one or more of the following services, functionality or operations: SSL VPN connectivity 280, switching/load balancing 284, Domain Name Service resolution 286, acceleration 288 and an application firewall 290 for communications between one or more clients 102 and one or more servers 106. Each of the servers 106 may provide one or more network related services 270*a*-270*n* (referred to as services 270). For example, a server 106 may provide an http service 270. The appliance 200 comprises one or more virtual servers or virtual internet protocol servers, referred to as a vServer, VIP server, or just VIP 275*a*-275*n* (also referred herein as vServer 275). The vServer 275 receives, intercepts or otherwise processes communications between a client 102 and a server 106 in accordance with the configuration and operations of the appliance 200.

The vServer 275 may comprise software, hardware or any combination of software and hardware. The vServer 275 may comprise any type and form of program, service, task, process or executable instructions operating in user mode 202, kernel mode 204 or any combination thereof in the appliance 200. The vServer 275 includes any logic, functions, rules, or operations to perform any embodiments of the techniques described herein, such as SSL VPN 280, switching/load balancing 284, Domain Name Service resolution 286, acceleration 288 and an application firewall 290. In some embodiments, the vServer 275 establishes a connection to a service 270 of a server 106. The service 275 may comprise any program, application, process, task or set of executable instructions capable of connecting to and communicating to the appliance 200, client 102 or vServer 275. For example, the service 275 may comprise a web server, http server, ftp, email or database server. In some embodiments, the service 270 is a daemon process or network driver for listening, receiving and/or sending communications for an application, such as email, database or an enterprise application. In some embodiments, the service 270 may communicate on a specific IP address, or IP address and port.

In some embodiments, the vServer **275** applies one or more policies of the policy engine **236** to network communications between the client **102** and server **106**. In one embodiment, the policies are associated with a VServer **275**. In another embodiment, the policies are based on a user, or a group of users. In yet another embodiment, a policy is global and applies to one or more vServers **275***a*-**275***n*, and any user or group of users communicating via the appliance **200**. In some embodiments, the policies of the policy engine have conditions upon which the policy is applied based on any content of the communication, such as internet protocol address, port, protocol type, header or fields in a packet, or the context of the communication, such as user, group of the user, vServer **275**, transport layer connection, and/or identification or attributes of the client **102** or server **106**.

In other embodiments, the appliance **200** communicates or interfaces with the policy engine **236** to determine authentication and/or authorization of a remote user or a remote client **102** to access the computing environment **15**, application, and/or data file from a server **106**. In another embodiment, the appliance **200** communicates or interfaces with the policy engine **236** to determine authentication and/or authorization of a remote user or a remote client **102** to have the application delivery system **190** deliver one or more of the computing environment **15**, application, and/or data file. In yet another embodiment, the appliance **200** establishes a VPN or SSL VPN connection based on the policy engine's **236** authentication and/or authorization of a remote user or a remote client **103** In one embodiment, the appliance **102** controls the flow of network traffic and communication sessions based on policies of the policy engine **236**. For example, the appliance **200** may control the access to a computing environment **15**, application or data file based on the policy engine **236**.

In some embodiments, the vServer **275** establishes a transport layer connection, such as a TCP or UDP connection with a client **102** via the client agent **120**. In one embodiment, the vServer **275** listens for and receives communications from the client **102**. In other embodiments, the vServer **275** establishes a transport layer connection, such as a TCP or UDP connection with a client server **106**. In one embodiment, the vServer **275** establishes the transport layer connection to an internet protocol address and port of a server **270** running on the server **106**. In another embodiment, the vServer **275** associates a first transport layer connection to a client **102** with a second transport layer connection to the server **106**. In some embodiments, a vServer **275** establishes a pool of transport layer connections to a server **106** and multiplexes client requests via the pooled transport layer connections.

In some embodiments, the appliance **200** provides a SSL VPN connection **280** between a client **102** and a server **106**. For example, a client **102** on a first network **102** requests to establish a connection to a server **106** on a second network **104'**. In some embodiments, the second network **104'** is not routable from the first network **104**. In other embodiments, the client **102** is on a public network **104** and the server **106** is on a private network **104'**, such as a corporate network. In one embodiment, the client agent **120** intercepts communications of the client **102** on the first network **104**, encrypts the communications, and transmits the communications via a first transport layer connection to the appliance **200**. The appliance **200** associates the first transport layer connection on the first network **104** to a second transport layer connection to the server **106** on the second network **104**. The appliance **200** receives the intercepted communication from the client agent **102**, decrypts the communications, and transmits the communication to the server **106** on the second network **104** via the second transport layer connection. The second transport layer connection may be a pooled transport layer connection. As such, the appliance **200** provides an end-to-end secure transport layer connection for the client **102** between the two networks **104**, **104'**.

In one embodiment, the appliance **200** hosts an intranet internet protocol or intranetIP **282** address of the client **102** on the virtual private network **104**. The client **102** has a local network identifier, such as an internet protocol (IP) address and/or host name on the first network **104**. When connected to the second network **104'** via the appliance **200**, the appliance **200** establishes, assigns or otherwise provides an IntranetIP, which is network identifier, such as IP address and/or host name, for the client **102** on the second network **104'**. The appliance **200** listens for and receives on the second or private network **104'** for any communications directed towards the client **102** using the client's established IntranetIP **282**. In one embodiment, the appliance **200** acts as or on behalf of the client **102** on the second private network **104**. For example, in another embodiment, a vServer **275** listens for and responds to communications to the IntranetIP **282** of the client **102**. In some embodiments, if a computing device **100** on the second network **104'** transmits a request, the appliance **200** processes the request as if it were the client **102**. For example, the appliance **200** may respond to a ping to the client's IntranetIP **282**. In another example, the appliance may establish a connection, such as a TCP or UDP connection, with computing device **100** on the second network **104** requesting a connection with the client's IntranetIP **282**.

In some embodiments, the appliance **200** provides one or more of the following acceleration techniques **288** to communications between the client **102** and server **106**: 1) compression; 2) decompression; 3) Transmission Control Protocol pooling; 4) Transmission Control Protocol multiplexing; 5) Transmission Control Protocol buffering; and 6) caching. In one embodiment, the appliance **200** relieves servers **106** of much of the processing load caused by repeatedly opening and closing transport layers connections to clients **102** by opening one or more transport layer connections with each server **106** and maintaining these connections to allow repeated data accesses by clients via the Internet. This technique is referred to herein as "connection pooling".

In some embodiments, in order to seamlessly splice communications from a client **102** to a server **106** via a pooled transport layer connection, the appliance **200** translates or multiplexes communications by modifying sequence number and acknowledgment numbers at the transport layer protocol level. This is referred to as "connection multiplexing". In some embodiments, no application layer protocol interaction is required. For example, in the case of an in-bound packet (that is, a packet received from a client **102**), the source network address of the packet is changed to that of an output port of appliance **200**, and the destination network address is changed to that of the intended server. In the case of an outbound packet (that is, one received from a server **106**), the source network address is changed from that of the server **106** to that of an output port of appliance **200** and the destination address is changed from that of appliance **200** to that of the requesting client **102**. The sequence numbers and acknowledgment numbers of the packet are also translated to sequence numbers and acknowledgement expected by the client **102** on the appliance's **200** transport layer connection to the client **102**. In some embodiments, the packet checksum of the transport layer protocol is recalculated to account for these translations.

In another embodiment, the appliance **200** provides switching or load-balancing functionality **284** for communications between the client **102** and server **106**. In some

embodiments, the appliance **200** distributes traffic and directs client requests to a server **106** based on layer **4** or application-layer request data. In one embodiment, although the network layer or layer **2** of the network packet identifies a destination server **106**, the appliance **200** determines the server **106** to distribute the network packet by application information and data carried as payload of the transport layer packet. In one embodiment, the health monitoring programs **216** of the appliance **200** monitor the health of servers to determine the server **106** for which to distribute a client's request. In some embodiments, if the appliance **200** detects a server **106** is not available or has a load over a predetermined threshold, the appliance **200** can direct or distribute client requests to another server **106**.

In some embodiments, the appliance **200** acts as a Domain Name Service (DNS) resolver or otherwise provides resolution of a DNS request from clients **102**. In some embodiments, the appliance intercepts' a DNS request transmitted by the client **102**. In one embodiment, the appliance **200** responds to a client's DNS request with an IP address of or hosted by the appliance **200**. In this embodiment, the client **102** transmits network communication for the domain name to the appliance **200**. In another embodiment, the appliance **200** responds to a client's DNS request with an IP address of or hosted by a second appliance **200'**. In some embodiments, the appliance **200** responds to a client's DNS request with an IP address of a server **106** determined by the appliance **200**.

In yet another embodiment, the appliance **200** provides application firewall functionality **290** for communications between the client **102** and server **106**. In one embodiment, the policy engine **236** provides rules for detecting and blocking illegitimate requests. In some embodiments, the application firewall **290** protects against denial of service (DoS) attacks. In other embodiments, the appliance inspects the content of intercepted requests to identify and block application-based attacks. In some embodiments, the rules/policy engine **236** comprises one or more application firewall or security control policies for providing protections against various classes and types of web or Internet based vulnerabilities, such as one or more of the following: 1) buffer overflow, 2) CGI-BIN parameter manipulation, 3) form/hidden field manipulation, 4) forceful browsing, 5) cookie or session poisoning, 6) broken access control list (ACLs) or weak passwords, 7) cross-site scripting (XSS), 8) command injection, 9) SQL injection, 10) error triggering sensitive information leak, 11) insecure use of cryptography, 12) server misconfiguration, 13) back doors and debug options, 14) website defacement, 15) platform or operating systems vulnerabilities, and 16) zero-day exploits. In an embodiment, the application firewall **290** provides HTML form field protection in the form of inspecting or analyzing the network communication for one or more of the following: 1) required fields are returned, 2) no added field allowed, 3) read-only and hidden field enforcement, 4) drop-down list and radio button field conformance, and 5) form-field max-length enforcement. In some embodiments, the application firewall **290** ensures cookies are not modified. In other embodiments, the application firewall **290** protects against forceful browsing by enforcing legal URLs.

In still yet other embodiments, the application firewall **290** protects any confidential information contained in the network communication. The application firewall **290** may inspect or analyze any network communication in accordance with the rules or polices of the engine **236** to identify any confidential information in any field of the network packet. In some embodiments, the application firewall **290** identifies in the network communication one or more occurrences of a credit card number, password, social security number, name, patient code, contact information, and age. The encoded portion of the network communication may comprise these occurrences or the confidential information. Based on these occurrences, in one embodiment, the application firewall **290** may take a policy action on the network communication, such as prevent transmission of the network communication. In another embodiment, the application firewall **290** may rewrite, remove or otherwise mask such identified occurrence or confidential information.

Still referring to FIG. **2**B, the appliance **200** may include a performance monitoring agent **197** as discussed above in conjunction with FIG. **1**D. In one embodiment, the appliance **200** receives the monitoring agent **197** from the monitoring service **1908** or monitoring server **106** as depicted in FIG. **1**D. In some embodiments, the appliance **200** stores the monitoring agent **197** in storage, such as disk, for delivery to any client or server in communication with the appliance **200**. For example, in one embodiment, the appliance **200** transmits the monitoring agent **197** to a client upon receiving a request to establish a transport layer connection. In other embodiments, the appliance **200** transmits the monitoring agent **197** upon establishing the transport layer connection with the client **102**. In another embodiment, the appliance **200** transmits the monitoring agent **197** to the client upon intercepting or detecting a request for a web page. In yet another embodiment, the appliance **200** transmits the monitoring agent **197** to a client or a server in response to a request from the monitoring server **198**. In one embodiment, the appliance **200** transmits the monitoring agent **197** to a second appliance **200'** or appliance **205**.

In other embodiments, the appliance **200** executes the monitoring agent **197**. In one embodiment, the monitoring agent **197** measures and monitors the performance of any application, program, process, service, task or thread executing on the appliance **200**. For example, the monitoring agent **197** may monitor and measure performance and operation of vServers **275**A-**275**N. In another embodiment, the monitoring agent **197** measures and monitors the performance of any transport layer connections of the appliance **200**. In some embodiments, the monitoring agent **197** measures and monitors the performance of any user sessions traversing the appliance **200**. In one embodiment, the monitoring agent **197** measures and monitors the performance of any virtual private network connections and/or sessions traversing the appliance **200**, such an SSL VPN session. In still further embodiments, the monitoring agent **197** measures and monitors the memory, CPU and disk usage and performance of the appliance **200**. In yet another embodiment, the monitoring agent **197** measures and monitors the performance of any acceleration technique **288** performed by the appliance **200**, such as SSL offloading, connection pooling and multiplexing, caching, and compression. In some embodiments, the monitoring agent **197** measures and monitors the performance of any load balancing and/or content switching **284** performed by the appliance **200**. In other embodiments, the monitoring agent **197** measures and monitors the performance of application firewall **290** protection and processing performed by the appliance **200**.

C. Client Agent

Referring now to FIG. **3**, an embodiment of the client agent **120** is depicted. The client **102** includes a client agent **120** for establishing and exchanging communications with the appliance **200** and/or server **106** via a network **104**. In brief overview, the client **102** operates on computing device **100** having an operating system with a kernel mode **302** and a user mode **303**, and a network stack **310** with one or more layers **310***a*-

310*b*. The client **102** may have installed and/or execute one or more applications. In some embodiments, one or more applications may communicate via the network stack **310** to a network **104**. One of the applications, such as a web browser, may also include a first program **322**. For example, the first program **322** may be used in some embodiments to install and/or execute the client agent **120**, or any portion thereof. The client agent **120** includes an interception mechanism, or interceptor **350**, for intercepting network communications from the network stack **310** from the one or more applications.

The network stack **310** of the client **102** may comprise any type and form of software, or hardware, or any combinations thereof, for providing connectivity to and communications with a network. In one embodiment, the network stack **310** comprises a software implementation for a network protocol suite. The network stack **310** may comprise one or more network layers, such as any networks layers of the Open Systems Interconnection (OSI) communications model as those skilled in the art recognize and appreciate. As such, the network stack **310** may comprise any type and form of protocols for any of the following layers of the OSI model: 1) physical link layer, 2) data link layer, 3) network layer, 4) transport layer, 5) session layer, 6) presentation layer, and 7) application layer. In one embodiment, the network stack **310** may comprise a transport control protocol (TCP) over the network layer protocol of the internet protocol (IP), generally referred to as TCP/IP. In some embodiments, the TCP/IP protocol may be carried over the Ethernet protocol, which may comprise any of the family of IEEE wide-area-network (WAN) or local-area-network (LAN) protocols, such as those protocols covered by the IEEE 802.3. In some embodiments, the network stack **310** comprises any type and form of a wireless protocol, such as IEEE 802.11 and/or mobile internet protocol.

In view of a TCP/IP based network, any TCP/IP based protocol may be used, including Messaging Application Programming Interface (MAPI) (email), File Transfer Protocol (FTP), HyperText Transfer Protocol (HTTP), Common Internet File System (CIFS) protocol (file transfer), Independent Computing Architecture (ICA) protocol, Remote Desktop Protocol (RDP), Wireless Application Protocol (WAP), Mobile IP protocol, and Voice Over IP (VoIP) protocol. In another embodiment, the network stack **310** comprises any type and form of transport control protocol, such as a modified transport control protocol, for example a Transaction TCP (T/TCP), TCP with selection acknowledgements (TCP-SACK), TCP with large windows (TCP-LW), a congestion prediction protocol such as the TCP-Vegas protocol, and a TCP spoofing protocol. In other embodiments, any type and form of user datagram protocol (UDP), such as UDP over IP, may be used by the network stack **310**, such as for voice communications or real-time data communications.

Furthermore, the network stack **310** may include one or more network drivers supporting the one or more layers, such as a TCP driver or a network layer driver. The network drivers may be included as part of the operating system of the computing device **100** or as part of any network interface cards or other network access components of the computing device **100**. In some embodiments, any of the network drivers of the network stack **310** may be customized, modified or adapted to provide a custom or modified portion of the network stack **310** in support of any of the techniques described herein. In other embodiments, the acceleration program **120** is designed and constructed to operate with or work in conjunction with the network stack **310** installed or otherwise provided by the operating system of the client **102**.

The network stack **310** comprises any type and form of interfaces for receiving, obtaining, providing or otherwise accessing any information and data related to network communications of the client **102**. In one embodiment, an interface to the network stack **310** comprises an application programming interface (API). The interface may also comprise any function call, hooking or filtering mechanism, event or call back mechanism, or any type of interfacing technique. The network stack **310** via the interface may receive or provide any type and form of data structure, such as an object, related to functionality or operation of the network stack **310**. For example, the data structure may comprise information and data related to a network packet or one or more network packets. In some embodiments, the data structure comprises a portion of the network packet processed at a protocol layer of the network stack **310**, such as a network packet of the transport layer. In some embodiments, the data structure **325** comprises a kernel-level data structure, while in other embodiments, the data structure **325** comprises a user-mode data structure. A kernel-level data structure may comprise a data structure obtained or related to a portion of the network stack **310** operating in kernel-mode **302**, or a network driver or other software running in kernel-mode **302**, or any data structure obtained or received by a service, process, task, thread or other executable instructions running or operating in kernel-mode of the operating system.

Additionally, some portions of the network stack **310** may execute or operate in kernel-mode **302**, for example, the data link or network layer, while other portions execute or operate in user-mode **303**, such as an application layer of the network stack **310**. For example, a first portion **310***a* of the network stack may provide user-mode access to the network stack **310** to an application while a second portion **310***a* of the network stack **310** provides access to a network. In some embodiments, a first portion **310***a* of the network stack may comprise one or more upper layers of the network stack **310**, such as any of layers **5-7**. In other embodiments, a second portion **310***b* of the network stack **310** comprises one or more lower layers, such as any of layers **1-4**. Each of the first portion **310***a* and second portion **310***b* of the network stack **310** may comprise any portion of the network stack **310**, at any one or more network layers, in user-mode **203**, kernel-mode, **202**, or combinations thereof, or at any portion of a network layer or interface point to a network layer or any portion of or interface point to the user-mode **203** and kernel-mode **203**.

The interceptor **350** may comprise software, hardware, or any combination of software and hardware. In one embodiment, the interceptor **350** intercept a network communication at any point in the network stack **310**, and redirects or transmits the network communication to a destination desired, managed or controlled by the interceptor **350** or client agent **120**. For example, the interceptor **350** may intercept a network communication of a network stack **310** of a first network and transmit the network communication to the appliance **200** for transmission on a second network **104**. In some embodiments, the interceptor **350** comprises any type interceptor **350** comprises a driver, such as a network driver constructed and designed to interface and work with the network stack **310**. In some embodiments, the client agent **120** and/or interceptor **350** operates at one or more layers of the network stack **310**, such as at the transport layer. In one embodiment, the interceptor **350** comprises a filter driver, hooking mechanism, or any form and type of suitable network driver interface that interfaces to the transport layer of the network stack, such as via the transport driver interface (TDI). In some embodiments, the interceptor **350** interfaces to a first protocol layer, such as the transport layer and another protocol layer, such as

any layer above the transport protocol layer, for example, an application protocol layer. In one embodiment, the interceptor **350** may comprise a driver complying with the Network Driver Interface Specification (NDIS), or a NDIS driver. In another embodiment, the interceptor **350** may comprise a min-filter or a mini-port driver. In one embodiment, the interceptor **350**, or portion thereof, operates in kernel-mode **202**. In another embodiment, the interceptor **350**, or portion thereof, operates in user-mode **203**. In some embodiments, a portion of the interceptor **350** operates in kernel-mode **202** while another portion of the interceptor **350** operates in user-mode **203**. In other embodiments, the client agent **120** operates in user-mode **203** but interfaces via the interceptor **350** to a kernel-mode driver, process, service, task or portion of the operating system, such as to obtain a kernel-level data structure **225**. In further embodiments, the interceptor **350** is a user-mode application or program, such as application.

In one embodiment, the interceptor **350** intercepts any transport layer connection requests. In these embodiments, the interceptor **350** execute transport layer application programming interface (API) calls to set the destination information, such as destination IP address and/or port to a desired location for the location. In this manner, the interceptor **350** intercepts and redirects the transport layer connection to a IP address and port controlled or managed by the interceptor **350** or client agent **120**. In one embodiment, the interceptor **350** sets the destination information for the connection to a local IP address and port of the client **102** on which the client agent **120** is listening. For example, the client agent **120** may comprise a proxy service listening on a local IP address and port for redirected transport layer communications. In some embodiments, the client agent **120** then communicates the redirected transport layer communication to the appliance **200**.

In some embodiments, the interceptor **350** intercepts a Domain Name Service (DNS) request. In one embodiment, the client agent **120** and/or interceptor **350** resolves the DNS request. In another embodiment, the interceptor transmits the intercepted DNS request to the appliance **200** for DNS resolution. In one embodiment, the appliance **200** resolves the DNS request and communicates the DNS response to the client agent **120**. In some embodiments, the appliance **200** resolves the DNS request via another appliance **200'** or a DNS server **106**.

In yet another embodiment, the client agent **120** may comprise two agents **120** and **120'**. In one embodiment, a first agent **120** may comprise an interceptor **350** operating at the network layer of the network stack **310**. In some embodiments, the first agent **120** intercepts network layer requests such as Internet Control Message Protocol (ICMP) requests (e.g., ping and traceroute). In other embodiments, the second agent **120'** may operate at the transport layer and intercept transport layer communications. In some embodiments, the first agent **120** intercepts communications at one layer of the network stack **210** and interfaces with or communicates the intercepted communication to the second agent **120'**.

The client agent **120** and/or interceptor **350** may operate at or interface with a protocol layer in a manner transparent to any other protocol layer of the network stack **310**. For example, in one embodiment, the interceptor **350** operates or interfaces with the transport layer of the network stack **310** transparently to any protocol layer below the transport layer, such as the network layer, and any protocol layer above the transport layer, such as the session, presentation or application layer protocols. This allows the other protocol layers of the network stack **310** to operate as desired and without modification for using the interceptor **350**. As such, the client agent **120** and/or interceptor **350** can interface with the transport layer to secure, optimize, accelerate, route or load-balance any communications provided via any protocol carried by the transport layer, such as any application layer protocol over TCP/IP.

Furthermore, the client agent **120** and/or interceptor may operate at or interface with the network stack **310** in a manner transparent to any application, a user of the client **102**, and any other computing device, such as a server, in communications with the client **102**. The client agent **120** and/or interceptor **350** may be installed and/or executed on the client **102** in a manner without modification of an application. In some embodiments, the user of the client **102** or a computing device in communications with the client **102** are not aware of the existence, execution or operation of the client agent **120** and/or interceptor **350**. As such, in some embodiments, the client agent **120** and/or interceptor **350** is installed, executed, and/or operated transparently to an application, user of the client **102**, another computing device, such as a server, or any of the protocol layers above and/or below the protocol layer interfaced to by the interceptor **350**.

The client agent **120** includes an acceleration program **302**, a streaming client **306**, a collection agent **304**, and/or monitoring agent **197**. In one embodiment, the client agent **120** comprises an Independent Computing Architecture (ICA) client, or any portion thereof, developed by Citrix Systems, Inc. of Fort Lauderdale, Fla., and is also referred to as an ICA client. In some embodiments, the client **120** comprises an application streaming client **306** for streaming an application from a server **106** to a client **102**. In some embodiments, the client agent **120** comprises an acceleration program **302** for accelerating communications between client **102** and server **106**. In another embodiment, the client agent **120** includes a collection agent **304** for performing end-point detection/scanning and collecting end-point information for the appliance **200** and/or server **106**.

In some embodiments, the acceleration program **302** comprises a client-side acceleration program for performing one or more acceleration techniques to accelerate, enhance or otherwise improve a client's communications with and/or access to a server **106**, such as accessing an application provided by a server **106**. The logic, functions, and/or operations of the executable instructions of the acceleration program **302** may perform one or more of the following acceleration techniques: 1) multi-protocol compression, 2) transport control protocol pooling, 3) transport control protocol multiplexing, 4) transport control protocol buffering, and 5) caching via a cache manager. Additionally, the acceleration program **302** may perform encryption and/or decryption of any communications received and/or transmitted by the client **102**. In some embodiments, the acceleration program **302** performs one or more of the acceleration techniques in an integrated manner or fashion. Additionally, the acceleration program **302** can perform compression on any of the protocols, or multiple-protocols, carried as a payload of a network packet of the transport layer protocol. The streaming client **306** comprises an application, program, process, service, task or executable instructions for receiving and executing a streamed application from a server **106**. A server **106** may stream one or more application data files to the streaming client **306** for playing, executing or otherwise causing to be executed the application on the client **102**. In some embodiments, the server **106** transmits a set of compressed or packaged application data files to the streaming client **306**. In some embodiments, the plurality of application files are compressed and stored on a file server within an archive file such as a CAB, ZIP, SIT, TAR, JAR or other archive. In one embodiment, the server **106** decom-

presses, unpackages or unarchives the application files and transmits the files to the client **102**. In another embodiment, the client **102** decompresses, unpackages or unarchives the application files. The streaming client **306** dynamically installs the application, or portion thereof, and executes the application. In one embodiment, the streaming client **306** may be an executable program. In some embodiments, the streaming client **306** may be able to launch another executable program.

The collection agent **304** comprises an application, program, process, service, task or executable instructions for identifying, obtaining and/or collecting information about the client **102**. In some embodiments, the appliance **200** transmits the collection agent **304** to the client **102** or client agent **120**. The collection agent **304** may be configured according to one or more policies of the policy engine **236** of the appliance. In other embodiments, the collection agent **304** transmits collected information on the client **102** to the appliance **200**. In one embodiment, the policy engine **236** of the appliance **200** uses the collected information to determine and provide access, authentication and authorization control of the client's connection to a network **104**.

In one embodiment, the collection agent **304** comprises an end-point detection and scanning mechanism, which identifies and determines one or more attributes or characteristics of the client. For example, the collection agent **304** may identify and determine any one or more of the following client-side attributes: 1) the operating system an/or a version of an operating system, 2) a service pack of the operating system, 3) a running service, 4) a running process, and 5) a file. The collection agent **304** may also identify and determine the presence or versions of any one or more of the following on the client: 1) antivirus software, 2) personal firewall software, 3) anti-spam software, and 4) internet security software. The policy engine **236** may have one or more policies based on any one or more of the attributes or characteristics of the client or client-side attributes.

In some embodiments, the client agent **120** includes a monitoring agent **197** as discussed in conjunction with FIGS. **1**D and **2**B. The monitoring agent **197** may be any type and form of script, such as Visual Basic or Java script. In one embodiment, the monitoring agent **129** monitors and measures performance of any portion of the client agent **120**. For example, in some embodiments, the monitoring agent **129** monitors and measures performance of the acceleration program **302**. In another embodiment, the monitoring agent **129** monitors and measures performance of the streaming client **306**. In other embodiments, the monitoring agent **129** monitors and measures performance of the collection agent **304**. In still another embodiment, the monitoring agent **129** monitors and measures performance of the interceptor **350**. In some embodiments, the monitoring agent **129** monitors and measures any resource of the client **102**, such as memory, CPU and disk.

The monitoring agent **197** may monitor and measure performance of any application of the client. In one embodiment, the monitoring agent **129** monitors and measures performance of a browser on the client **102**. In some embodiments, the monitoring agent **197** monitors and measures performance of any application delivered via the client agent **120**. In other embodiments, the monitoring agent **197** measures and monitors end user response times for an application, such as web-based or HTTP response times. The monitoring agent **197** may monitor and measure performance of an ICA or RDP client. In another embodiment, the monitoring agent **197** measures and monitors metrics for a user session or application session. In some embodiments, monitoring agent **197** measures and monitors an ICA or RDP session. In one embodiment, the monitoring agent **197** measures and monitors the performance of the appliance **200** in accelerating delivery of an application and/or data to the client **102**.

In some embodiments and still referring to FIG. **3**, a first program **322** may be used to install and/or execute the client agent **120**, or portion thereof, such as the interceptor **350**, automatically, silently, transparently, or otherwise. In one embodiment, the first program **322** comprises a plugin component, such an ActiveX control or Java control or script that is loaded into and executed by an application. For example, the first program comprises an ActiveX control loaded and run by a web browser application, such as in the memory space or context of the application. In another embodiment, the first program **322** comprises a set of executable instructions loaded into and run by the application, such as a browser. In one embodiment, the first program **322** comprises a designed and constructed program to install the client agent **120**. In some embodiments, the first program **322** obtains, downloads, or receives the client agent **120** via the network from another computing device. In another embodiment, the first program **322** is an installer program or a plug and play manager for installing programs, such as network drivers, on the operating system of the client **102**.

D. Load Balancing with Metrics Selected by a User from Appliance Determined Metrics and/or Metrics Collected from a Device Via a Network Management Protocol

Referring now to FIGS. **4**A and **4**B, systems and methods are depicted for load balancing based on metrics determined by the appliance **200** and/or metrics collected by the appliance from a device or service via a network management protocol, such as a Simple Network Management Protocol (SNMP). The appliance provides a load monitor to monitor the load of one or more services **270***a*-**270***n*. In one embodiment, a user may configure one or more load monitors based on metrics selected from a custom metric table which includes metrics or objects obtains via a network management protocol query. In another embodiment, a user may configure one or more load monitors based on metrics or parameters collected by the appliance. In some embodiments, the user configures one or more load monitors based on metrics selected from the custom metric table and the appliance collected metrics. In response to the user's selection, the appliance determines the load of the one or more services and load balances client requests to the services using any type of load balancing technique.

Referring now to FIG. **4**A, an embodiment of an appliance for load balancing one or more services is depicted. In brief overview, an appliance **200** has one or more virtual servers, or vServers **275**A-**275**N configured to provide load balancing **284** to one or more services **270***a*-**270***n* deployed on or provided by one or more servers **106***a*-**106***b*. A vServer **275**A is associated with, configured to or bound to a service **270**A or a group of services **270**A-**270**N. The appliance **200** has one or more load monitors **405**A-**405**N to monitor a status, operation, and/or performance of the services **270**A-**270**N. A load monitor is associated with, configured to or bound to a service **270**A or a group of services **270**A-**270**N. The load monitors **405**A-**405**B provide information to the vServers **275**A-**275**N to determine which of the services **270**A-**270**N should receive a request received by a vServer **275**. A load monitor **405** and/or vServer **275** may use appliance collected metrics **410** and/or device provided metrics **420** to determine a load across a plurality of services **270**A-**270**N and to load balancing incoming client requests. The appliance **200** also includes a configuration interface **435** to receive information identifying user selected or user defined metrics **430** to be used by the

load monitors **405** and/or vServers **275** for load balancing the plurality of services **270**A-**270**N.

The appliance **200** may include any type and form of load monitor **405**A-**405**N, also referred to as monitoring agent, for monitoring any operational or performance characteristic or metric of a service **270**, server **106** or device **100**. A load monitor **405** may include software, hardware, or any combination of software and hardware. The load monitor **405** may include any application, program, script, service, daemon, process, task, thread or set of executable instructions. In one embodiment, the load monitor **405** operates or executes in kernel space of the appliance **200**. In another embodiment, the load monitor **405** operates or executes in user or application space of the appliance **200**. In some embodiments, a first portion of the load monitor **405** operates in kernel space while a second portion of the load monitor **405** operates in application layer or space of the appliance **200**.

In one embodiment, the load monitor **405** communicates with a service **270** once. In some embodiments, the load monitor **405** monitors or communicates with a service **270** on a predetermined frequency, such as every 1 msec or 1 sec. A user may configure or specify the predetermined frequency via the configuration interface **425**. In other cases, another appliance or system may configure or specify the predetermined frequency via the configuration interface **425**. In yet another embodiment, the load monitor **405** monitors or communicates with a service **270** responsive to one or more events, such as receipt of a request, response or a network packet. In one embodiment, a load monitor **405** monitors or communicates with a service **270** responsive to one or more policies of a policy engine.

In some embodiments, a load monitor **405** may use a request/reply messaging mechanism or protocol with the service **270** or server **106**. In other embodiments, a load monitor **405** may have a custom or proprietary exchange protocol for communicating with a service, server or device. In one embodiment, a load monitor **405** may use the protocol of the service **270** to monitor or communicate with the service **270**. As such, in some embodiments, the load monitor **405** uses the HTTP protocol to monitor or communicate with a web service **270**A or an FTP protocol for an FTP server **270**B. In yet other embodiments, the load monitor **405** uses a TCP or ICMP protocol for monitoring a service **270**. In some embodiments, the load monitor **405** uses a network management protocol to monitor or query a status or metric of a service, server or device. In one embodiment, the load monitor **405** uses a Simple Network Management Protocol (SNMP). In another embodiment, the load monitor **405** uses a common management information protocol (CIMP).

In some embodiments, a single load monitor **405** monitors a plurality of services **270**A-**270**N, or servers **106**A-**106**B. In other embodiments, a plurality of load monitors **405**A-**405**N monitor a single service **270**A or server **106**A. In still other embodiments, multiple load monitors **405** may each monitor a plurality of services **270**A-**270**N, or servers **106**A-**106**N. In one embodiment, multiple load monitors **405** may each monitor a service **270**. In yet another embodiment, a load monitor **405**A may monitor one or more other load monitors **405**B-**405**N.

In some embodiments, the one or more load monitors **405** are associated with one or more services **270**. In one embodiment, a user specifies or configures a load monitor **405** for one or more service **270** via the configuration interface **425**. For example, a user via the configuration interface **435** may issue a command to bind the monitor **405** to a service **275**. In other embodiments, the load monitor **405** is associated with a vServer **275**. In one embodiment, a user specifies or configures via the configuration interface **425** a load monitor **405** for a vServer **275**. In yet another embodiment, a use specifies or configures via the configuration interface **425** a vServer **275** for one or more services **270**A-**270**N. For example, a user may bind a vServer **275** to a service **270**.

In some embodiments, the one or more load monitors **405** may monitor an appliance **200**, vServer **275**, network service **270**, client **102**, server **106**, device **100** or any other network resource. In one embodiment, a user specifies a type of network service to associate with the one or more monitoring agents **405**. In another embodiment, a user customizes a monitoring agent. For example, a user may implement or otherwise provide a script for monitoring a service. In still another embodiment, a generic monitoring agent **405** is used. In some embodiments, a monitor agent **405** is configurable to use a predetermined monitor, script or status message based on a type of protocol or type of service

In yet another embodiment, the one or more monitoring agents **405** determine the response time of the one or more network services **270** for responding to a request of one of the following types: ping, transport control protocol (tcp), tcp extended content verification, hypertext transfer protocol (http), http extended content verification, hypertext transfer protocol secure (https), https extended content verification, user datagram protocol, domain name service, and file transfer protocol. In some embodiment, a monitoring agent **405** checks for predetermined status codes in responses from the service **270**. In other embodiments, the monitoring agent **405** checks for predetermined string patters in response from the service **270**.

In some embodiments, the one or more load monitors or monitoring agents **405** are protocol-specific agents. For example, an agent **405** may determine availability for a network service of a particular protocol-type. In some embodiments, a monitoring agent **405** determines a response time of a server **106** or network service **270** to a TCP request. In one of these embodiments, the agent uses a "TCP/ICMP echo request" command to send a datagram to the network service **270**, receive a datagram from the network service **270** in response, and determine a response time based on the roundtrip time of the datagram. In another of these embodiments, the monitoring agent **405** verifies that the response from the network service **270** included expected content. In one embodiment, the monitoring agent **405** verifies that the response did not include an error.

In other embodiments, a monitoring agent **405** determines availability of a network service **270** to a UDP request. In one of these embodiments, the agent uses a "UDP echo" command to send a datagram to the network service **270**, receive a datagram from the network service **270** in response, and determine a response time based on the roundtrip time of the datagram. In another of these embodiments, the monitoring agent **405** verifies that the response from the network service **270** included expected content and did not contain errors.

In still other embodiments, the monitoring agent **405** determines availability of a network service **270** to an FTP request. In one of these embodiments, the monitoring agent **405** sends an FTP command, such as a "get" command or a "put" command, to the network service **270** and determines a time needed by the network service **270** to respond to the command. In another of these embodiments, the monitoring agent **405** verifies that the response from the network service **270** included expected content, such as contents of a file requested by a "get" command, and did not contain errors.

In yet other embodiments, the monitoring agent **405** determines availability of a network service **270** to an HTTP request. In one of these embodiments, the monitoring agent

405 sends an HTTP command, such as a "get" request for a uniform resource locator (URL) or a file, to the network service 270 and determines a time needed by the network service 270 to respond to the request. In another of these embodiments, the monitoring agent 405 verifies that the response from the network service 270 included expected content, such as the content of a web page identified by a URL. In some embodiment, the monitor agent 405 checks for a predetermined status code. In other embodiments, the monitoring agent 405 checks for a predetermine string pattern in an HTTP response.

In further embodiments, the monitoring agent 405 determines availability of a network service 270 to a DNS request. In one of these embodiments, the monitoring agent 405 sends a DNS request, such as a dnsquery or nslookup for a known network address, to the server 106 or network service 270 and determines a time needed by the server 106 or network service 270 to respond to the request. In another of these embodiments, the monitoring agent 405 verifies that the response from the network service 270 included expected content, such as the domain name of a computing device 100 associated with the known network address. In one embodiment, monitoring agent 405 verifies the response did not have an error.

In some embodiments, the appliance 200 via a monitoring agent 405 identifies and collects metrics 410 based on network traffic and information traversing the appliance, or otherwise referred to as appliance collected parameters or metrics. The appliance 200 or agent 405 may store the appliance collected metrics 410 in any type and form of data storage mechanism in memory and/or disk storage. In one embodiment, the appliance stores the metrics 410 in a table. In another embodiment, the appliance stores the metrics 410 in a database. In yet another embodiment, the appliance stores the metrics 410 in an object or data structure. In still other embodiments, the appliance 200 stores appliance collected metrics 410 in multiple tables and/or data storage mechanisms. In one embodiments, the appliance collected metrics 410 may be arranged or organized in any manner in the multiple tables.

In some embodiments, the monitoring agent 405 determines one or more metrics 410 from network packets received and transmitted by the appliance. In one embodiment, the monitoring agent 405 determines a number and/or type of connections to one or more services 270 or server 106. In another embodiment, the monitoring agent 405 determines a number of packets transmitted to a service 270 or server 106. In other embodiments, the monitoring agents 405 determines a number of packets received from or transmitted by a service 270 or server 106. In some embodiments, the monitoring agent 405 determines a response time from a service 270 or service. In one embodiments, the monitoring agent 405 determines an average response time. In another embodiment, the monitoring agent 405 determines a number or percentage of loss packets. In other embodiments, the monitoring agent 405 determines a number of errors received from a service or server.

In some embodiments, the monitoring agent 405 determines a bandwidth of a connection to a service 270 or a server 106. In one embodiment, the monitoring agent 405 determines the bandwidth of a connection based on a response time and/or packet loss. In another embodiment, the monitoring agent 405 determines the bandwidth of a connection based on a number of bytes transferred or communicated to and/or form a service 270 or server 106. In one embodiment, the monitoring agent 405 determines the bandwidth based on a number of bytes received from a service or server over a predetermined time period, such as per second. In another embodiment, the monitoring agent 405 determines the bandwidth based on a number of bytes transmitted to a service or server over a predetermined time period. In some embodiments, the monitoring agent 405 determines the bandwidth based on a number of bytes transmitted to and received from a service or server over a predetermined time period.

In some embodiments, the appliance 200 via a monitoring agent 405 identifies and collects metrics 430 provided by a service, server or device. These metrics 430 may also be referred to as custom metrics or a custom metric table. The appliance 200 or agent 405 may store the service or device collected metrics 430 in any type and form of data storage mechanism in memory and/or disk storage. In one embodiment, the appliance stores the metrics 430 in a table. In another embodiment, the appliance stores the metrics 430 in a database. In yet another embodiment, the appliance stores the metrics 430 in an object or data structure. In some embodiments, the appliance stores the metrics 430 in the same data storage mechanism as the appliance collected metrics 410. In other embodiments, the appliance stores the metrics 430 in a different storage mechanism as the appliance collected metrics 410. In still other embodiments, the appliance 200 stores device provided metrics 420 in multiple tables and/or data storage mechanisms. In one embodiments, the device provided metrics 420 may be arranged or organized in any manner in the multiple tables. For example, the appliance 200 may maintain a metrics table 420 for each service, device or application.

In one embodiment, the load monitor 405 uses a network management protocol, such as SNMP, to query a server or device for one or more objects identifiers and data for the objects of the object identifiers. By way of example only and not in any way limiting, the load monitor 405 uses an SNMP architecture to provide management information bases (MIBs) 417, which specify management data of a device or device subsystem, such as a service 270, using a hierarchical namespace containing object identifiers 422A-422N for managed objects. In some embodiments, a MIB 417 is a collection of information that is organized hierarchically. MIBs 417 may be accessed using a network-management protocol such as SNMP. An MIB 417 includes managed objects identified by object identifiers 422A-422N. In one embodiment, a managed object (sometimes called a MIB object, an object, or a MIB) is one of any number of characteristics or metrics of a managed device, appliance or system. In some embodiments, a managed objects includes one or more object instances, which correspond to or referred to as variables.

In one embodiment, the MIB 417 hierarchy may be depicted as a tree with a nameless root, the levels of which are assigned by different organizations. In some embodiments, the top-level MIB object IDs may belong to different standards organizations, while lower-level object IDs are allocated by associated organizations. The MIB 417 and/or objects 422A-422N may be arranged, constructed or organized for management across any of layers of the OSI reference model. In some embodiments, the MIB 417 and/or objects 422A-422N provide managed data and information on applications such as databases, email, and web services. Furthermore, the MIB 417 and/or objects 422A-422N may define for any area-specific or appliance specification information and operations, such as for any type of service 270, server 106 or device 100 load balanced or managed by the appliance 200.

In the example embodiment of SNMP, the SNMP communication model is based on a manager 415 and an agent 416 with a data of management information 417 and management objects 422A-422N. In one embodiment, the manager 415

provides an interface between appliance and the managed system. The agent **416** provides the interface between the manager **415** and the device, system, application, component, element or resource being managed. As illustrated in FIG. **4**A, the appliance **200** may include a manager **415** which requests and obtains object identifiers and values from an agent **416**, such as the agent **416** on a server **106**. In the example of SNMP, a manager **415** communicates a GET or GET-NEXT message to request information for a specific object. The agent **416**, in response to the manger's request, issues a GET-RESPONSE message to the manager **415** with the information requested or an error message. The manager **415** may transmit a SET message to request a change to a value of a specific variable or object **422**. The agent **416** may issue a TRAP message to inform the manager **415** of an event, such as an alarm or error on a service **270**.

Although generally described in an embodiment of an SNMP network management protocol, the appliance **200** and/or load monitor **405** may use any type and form of network management protocol and communication model to obtain identifiers and values of information, such as objects or variables, from another device for a managed system, subsystem or service **270**. For example, the appliance **200** may use any of the following protocols and/or communication models: Remote monitoring (RMON), AgentX, Simple Gateway Monitoring Protocol (SGMP), Common management information protocol (CMIP), Common management information service (CMIS) or CMIP over TCP/IP (CMOT).

Furthermore, although a MIB **417** is generally described in reference to a manager/agent communication model for an example network management protocol such as SNMP, the MIB **417** may include any type and form of data storage of object identifiers, variables, parameters or other identifiers of metrics. The MIB **417** may be either protocol dependent or protocol independent. For example, the MIB **417** may comprise a table of metrics for a device or service that can be queried via any type and form of API.

The managed objects or variables provided via the network management protocol may provide any type and form of metrics or operational characteristics of the service, server or device to be used by the appliance for load balancing, or any other function of the appliance **200**. In one embodiment, the device provided metrics **420** may include any of the metrics **410** collected by the appliance as described above. In another embodiment, the device provided metrics **420** may include any type and form of information on any resource usage of the managed device, service or system. In one embodiment, the metrics **410** include CPU, memory and/or disk usage of the device and/or service **270**. In other embodiments, the metrics **420** may include information on a number of connections, sessions or clients of the service **270**. In some embodiments, the metrics **420** include any information on any thresholds of the service **270** or server **106**, such as a threshold identifying a maximum number of sessions or clients. In yet another embodiment, the metrics **420** include any information on a type of protocol of the service **270**. In other embodiments, the metrics **420** include any information on any alarms or errors of the service **270**.

In some embodiments, each load monitor **405** includes the appliance collected metrics **410**. For example, the metric table **410** may be implicitly bound to each monitor **405** by default. In other embodiments, a user associates or binds a custom metric table **420** to a monitor **405**. In yet another embodiment, a user associates or binds a custom metric table **420** and appliance collected table **410** to a monitor **405**. In yet other embodiments, a user may associate or bind any combination of one or more appliance collected metric tables **410** and custom metric tables **420** to one or more load monitors **405**.

In some embodiments, a user via the configuration interface **425** may configure or specify for a load monitor **405** one or more object identifiers **422**A-**422**N to obtain values for and store in the metrics **420**. For example, the user may specify a user-defined metric **430**. In other embodiments, the appliance **200** or load monitor **405** obtains a list of one or more object identifiers **422**A-**4222**N from a device **100**, such as server **106** or service **270**. In yet another embodiment, the appliance **200** includes one or more metric tables **420** with predetermined OIDS **422**A-**422**N for a known device. For example, the appliance **200** may include a metric table **420** for any one or more of the following appliances or devices: 1) any version of the NetScaler device manufactured by Citrix Systems, Inc. of Ft. Lauderdale, Fla.; 2) any of the appliances, such as BIGIP or WebAccelerator, manufactured by F5 Networks, Inc. of Seattle, Wash.; 3) any of the AppDirector or AppXcel devices manufactured by Radware Ltd of Mahwah, N.J.; 4) any application acceleration and/or security related appliances and/or software manufactured by Cisco Systems, Inc. of San Jose, Calif.

The appliance **200**, vServer **275** and/or load monitor **405** computes, calculates or otherwise determines a load **440** for each service **270** based on any of the metrics from the appliance collected metrics **410** and/or device provided metrics **420**. The appliance **200** may use a weight **435**A-**435**N and a threshold **437**A-**437**N for each of the metrics used in the determination of the load **440**. In one embodiment, the appliance **200** establishes a weight **435** and/or a threshold **437**. In other embodiments, a user establishes a weight **435** and/or a threshold **437**. For example, in some cases, if a user does not specify a weight for a plurality of metrics, the appliance equally weights each metric. In one example embodiment, the appliance **200** determines the load **440** for each service as follows:

Sum(weight of metric/established ceiling value of metric)*(obtained value of metric/established ceiling value of metric))/Sum(weights))

In some embodiments, a metric value may be based on a range of 0-100, or absolute range. In other embodiments, a metric value may not be based on a range of 0-100 or is otherwise relative to the type of metric and possible range of values. For example, a metric identifying a number of connections may have a ceiling or predetermined maximum value of 10,000. In one of these embodiments, the appliance establishes a ceiling value or predetermined upper limit for the metric value. In another of these embodiments, a user via the configuration interface **425** establishes a ceiling value or predetermined upper limit for the metric value. In further embodiments, the established ceiling value may comprise a value less than the actual maximum value for the metric or upper limit of the range value. For example, a user may specify or configure a relative range value based on a desired operational or performance range of a metric.

In some embodiments, if a metric of a service exceeds a user or appliance provided threshold, the service may be excluded from the load determination or otherwise from a load balancing decision. In other embodiments, if all the metrics of a service exceeds their corresponding thresholds, the service may be excluded from the load determination or otherwise from a load balancing decisions. In yet another embodiment, even if a service exceeds the threshold(s) for one or more of the metrics, the service may be considered in the load determination or otherwise for load selection. In

some cases, a client session may be identified as persistent or sticky to a vServer **275** or service **270**. In these cases, if a request for the client's sessions is received by the appliance, the appliance may provide the request to a vServer **275** or service **270** although a metric for the vServer or service has been exceeded.

In still other embodiments, if a threshold of a metric of a service or virtual server has been exceeded, the appliance may, in response to the threshold being exceeded, redirect the client making the request to another resource. In one embodiment, the appliance may transmit a URL to the client comprising the address of a server **106** or service **270** such that the client may bypass the appliance **200** and access the server **106** or service **270** directly. In one embodiment, the appliance may transmit a URL to the client comprising the address of a second appliance **200** or another device. In still another embodiment, the appliance **200** may redirect the client request to a second appliance, device, service or server on behalf of the client.

In some embodiments, if a threshold of a metric of a service or virtual server has been exceeded, the appliance may, in response to the threshold being exceeded direct a client request to a second virtual server or service. In one embodiment, a second virtual server may be a backup to a primary virtual server. Upon detection of the threshold being exceeded, the appliance may spillover requests and connections to a second virtual server.

Although the load **440** is generally discussed in view of the above equation, the appliance may use any type and form of load calculation, weighted or not weighted. In some embodiments, the appliance **200** determines the load using an average of metric values. In other embodiments, the appliance **200** determines the load **440** using any derivative value of a metric. In another embodiment, the appliance **200** determines the load **440** using any statistical measure of a metric. In still another embodiment, the appliance **200** determines the load **440** using any function or computation of a metric. In yet other embodiments, the appliance **200** may determine a load **440** for each metric. In these embodiments, the appliance **200** may aggregate, compare or otherwise compute an load **440** based on any type and form of aggregation of a metric's contribution to a load of a service.

In some embodiments, a user configures multiple monitors **405** for a service **270**. In these embodiments, the load **440** on the service **270** is a sum of the load of all the monitors. In one embodiment, the sum of the load from multiple monitors **440** is weighted. The appliance may assign a monitoring **405** a weight. A weight may comprise an integer, decimal, or any other numeric indicator. In some embodiments, a user may configure via the configuration interface **425** the weight corresponding to a monitor **405**. In some embodiments, all monitors **405** may be assigned equal weight. In other embodiments, a plurality of monitors **405** may each be assigned different weights. The weights may be assigned to the monitors based on any criteria indicating relative importance, including without limitation the appliance or user determination of the relative importance or value of the monitor in view of the service, reliability of the monitoring mechanism, and the frequency of monitoring.

In one embodiment, a monitoring agent **405** may be assigned a weight based on the relative importance of the service monitored by the appliance. For example, if most user requests in an environment are HTTP requests, a monitoring agent monitoring HTTP availability of a server **106** might be assigned a weight of 10, while a monitoring agent monitoring FTP availability of a server **106** might be assigned a weight of 3. Or, for example, if an administrator placed a high priority on UDP applications, a monitoring agent monitoring UDP availability of a server may be assigned a weight of 20, while a DNS monitoring agent may be assigned a weight of 5.

In some embodiments, an appliance **200** may compute a sum of the weights of the monitoring agents currently reporting a network service **270** as operational. For example, if five monitoring agents, each assigned a weight of 30, are monitoring a network service **270**, and three of the five monitoring agents report the network service **270** as available, the appliance may determine the sum of the monitoring agents currently reporting the network service **270** as operational to be 90. Or for example, if only two monitoring agents, one with a weight of 20 and the other with a weight of 40, are reporting a server **106** as available, the appliance may compute the sum of the monitoring agents currently reporting a server **106** as operational to be 60.

The appliance **200** also includes a configuration interface **425** providing any type and form of interface mechanism for a user, application or system to communicate with the appliance **200**. In one embodiment, the configuration interface **425** includes a command line interface **425**B. In another embodiment, the configuration interface **425** includes a graphical user interface **425**A. In some embodiments, the configuration interface **425** includes an application programming interface (API) or development toolkit for an application, program or script to communicate with the appliance **200**.

In some embodiments, the appliance **200** displays the configuration interface **425** via a display of the appliance. In other embodiments, a configuration terminal or device **100** connects to or communicates with the appliance **200** and displays the configuration interface **425**. For example, the configuration device **100** or terminal may connect to the appliance **200** via a port and IP address of the appliance **200**. The appliance **200** may provide a web service listening on the port and IP address to serve a page to the user. The served page may provide a user interface for configuring the appliance **200**. In other embodiments, the configuration terminal **100** may connect and communicate with the appliance **200** via any type and form of connection, including a monitor port, serial port or USB connection.

Via the configuration interface **425**, the appliance **200** may receive information identifying user selected metrics **430** to use in determining the load **440** for one or more services. In one embodiment, the user identifies or selects a metric from a plurality of appliance collected metrics **410**. In another embodiment, the user identifies or selects a metric from a plurality of device provided metrics **420**. In some embodiments, the user selects one or more metrics from the appliance collected metrics **510** and one or more metrics from the device provided metrics **410**. The appliance **200** may also receive via the configuration interface **425** information identifying a user's selection or designation of a weight **435** for a metric. For example, a user may provide a value of a weight **435** for a metric. In some embodiments, the appliance **200** receives information identifying a user provided value for a threshold **437**.

In operation, the appliance **200** may use user selected metrics **430** and user provided weights **435** and thresholds **437** for determining the load **440**. In another embodiment, the appliance may use any appliance established metrics from the appliance collected metrics **410** for determining the load. In one embodiment, a user establishes a weight and/or a threshold for an appliance provided metric. So although the metric may not be user selected in some embodiments, the user may control or configure the weights **435** and/or thresholds **437** for the metrics **410**. In other embodiments, the appliance may use any combination of user selected metrics **430** and appliance

established metrics **410** for determining the load. In another embodiment, the appliance **200** may use any combination of user provided weights **435** and/or thresholds **437** and appliance provided weights **435** and/or thresholds **437** for any metric used for determining the load **440**.

Referring now to FIG. **4**B, an embodiment of steps of a method for load balancing one or more services is depicted. In some embodiments, the appliance **200** may load balance one or more services using appliance collected metrics **410** and device provided metrics **420**. In other embodiments, the appliance **200** load balances one or more services based on user selected metrics, weights and/or thresholds. In brief overview, at step **455** of method **450**, multiple metrics are identified for load balancing a plurality of services **270**A-**270**N by the appliance **200**. At step **457**, in some embodiment, the appliance **200** receives user defined metrics to collect or monitor for a service **270**. At step **460**, the appliance receives user selected metrics from the set of identified metrics. The user may also identify weights and/or thresholds for the metric. At step **465**, the appliance determines a load for each of the services based on the user selected metric information. At step **470**, the appliance receives a client request to access a service. At step **475**, based on the load determination, the appliance determines a service from the plurality of services to transmit or forward the client request. At step **480**, the appliance transmits the client's request to the appliance selected service.

In further details, at step **455**, the appliance **200** identifies metrics to collect and monitor for load balancing one or more services **270**A-**270**N. In one embodiment, the appliance **200** provides or identifies one or more appliance collected metrics **410**. For example, a table **410** may identify metrics collected by the appliance **200**. In another embodiment, the appliance **200** provides one or more predetermined tables of device provided metrics **420**, such as for an appliance of Citrix, F5, Cisco, or Radware. In other embodiments, the appliances **200** identifies one or more metrics to collect via a network management protocol in an object or variable database, such as an MIB **417** for SNMP. In one embodiment, the appliance provides a preconfigured or preinstalled MIB **417** for a predetermined device or service **270**, such as an application.

In some embodiments, the appliance **200** queries a device or service **270** to determine available metrics to collect and/or monitor. For example, in one embodiment, the appliance **200** queries a device or service for available object identifiers **422**A-**422**N. In another embodiment, the appliance **200** uses a network management protocol, such as SNMP, to query for the identification of objects in a MIB **417**. In yet another embodiment, a user via the configuration interface **425** identifies one or more object identifiers **422**A-**422**N to collect and/or monitor from a device or service **270**, such as an application.

In some embodiments, at step **457**, a user specifies or defines a metric for the appliance to collect and/or monitor for a service **270**. For example, the user may specify via the configuration interface **425** an object identifier in a MIB **417**. In other embodiments, a user may configure or implement a load monitor **405** to collect and/or monitor a user-defined or specified metric. In yet another embodiment, a user, such as a network administrator, may configure, specify or implement one or more object identifiers **422** in a MIB **417** deployed on a server **106**. In some embodiments, the user may implement an application, program, script, service or other set of executable instructions to collect metrics on the server **106** and store values for the metrics in the MIB **417** on the server **106**. For example, the user may execute a program or script to monitor metrics of a service **270** on the server **106** and update the MIB **417** with the collected values. The manager **415** on the appliance **200** may query the agent **416** on the server for information and/or values of the metrics stored in the server's MIB **417** for the service **270**.

At step **460**, the appliance **200** receives information identifying a selection by a user of one or more metrics identified via the appliance. In some embodiments, a user via the configuration interface **425** selects one or more metrics provided via the appliance **200** to use for load balancing a server **270**. In one embodiment, the appliance **200** provides for selection by the user via the configuration interface **425** any one or more of the appliance collected metrics **410** or device provided metrics **420**. A user may configure the appliance **200** via a command line interface **425**B or graphical user interface **425**A to use one or more user selected metrics **430** for determining a load **440** or otherwise for load balancing services **270**A-**270**N by the appliance **200**.

In one embodiment, the appliance **200** receives information identifying that the user selected one or more appliance collected metrics **410**. In another embodiment, the appliance **200** receives information identifying that the user selected one or more device provided metrics **420**. In yet another embodiment, the appliance **200** receives information identifying that the user selected one or more appliance collected metrics **410** and one or more device provided metrics **420**.

Furthermore, via the configuration interface **425**, the appliance **200** may receive information identifying a user's designation or establishment of a weight **435** for a metric. In one embodiment, the appliance **200** receives a user's identification of a weight **435** for a user selected metric **430**. In another embodiment, the appliance **200** receives a user's identification of a weight **435** for an appliance established metric **410**. In other embodiments, the appliance **200** may receive information identifying a user's designation or establishment of a threshold **437** for a metric. In one embodiment, the appliance **200** receives a user's identification of a threshold **437** for a user selected metric **430**. In another embodiment, the appliance **200** receives a user's identification of a threshold **437** for an appliance established metric **410**.

At step **465**, the appliance determines a load for each of the one or more services. In one embodiment, a load monitor **405** collects and/or monitors one or more of the user selected metrics **430** for a service. In another embodiment, the load monitor **405** collects and/or monitors appliance collected metrics **410**. In some embodiments, a load monitor **405** collects metrics via a network management protocol, such as SNMP. In yet another embodiment, multiple load monitors **405**A-**405**N collect and/or monitor metrics for a service **270**. In one embodiment, although a user selected one or more metrics **430** for collecting and/or monitoring a service **270**, the appliance **200** collects and monitors any one or more appliance established metrics **410**, such as number of connections, response time, bandwidth, and number of packets, for the service **270**.

In some embodiments, a vServer **275** determines the load **440** for each service **270** via metric information collected and monitored by a load monitor **405**. In another embodiment, the load monitor **405** determines the load **440** for the service **270** being monitored. The appliance **200** and/or load monitor **405** may determine the load **440** using a user selected metric **430** weighted by a user designated weight **435**. In some embodiments, the appliance **200** and/or load monitor **405** determines the load **440** using a plurality of user selected metrics **430** weighted by user designated weights **435**. In yet another embodiment, the appliance **200** and/or load monitor **405** determines the load using a user selected metric **430** and user identified weight **435** and an appliance established metric **410**

and an appliance established weight **435**. In further embodiments, the appliance **200** determines the load **440** by summing a weighted load for each metric (user and/or appliance) used for the service **270**.

For the embodiment of multiple monitors **405**A-**405**N per service **270**, the appliance **200** may determine the load for the service by assigning a weight to each monitor and computing weighted load across all the monitors **405**. In other embodiments, the appliance **200** and/or load monitor **405** determines a load for a service **270** at a predetermined frequency, such as every 1 msec. or every 1 sec.

In some embodiments, a load monitor **405** determines that a metric for a service **270** has reached or exceed a threshold **437**. In other embodiments, a load monitor **405** determines that a metric for a service **270** is within a threshold **437**. In one embodiment, the load monitor **405** uses an appliance established or provided threshold for a metric. In another embodiment, the load monitor **405** user a user specified or configured threshold **437**.

At step **470**, the appliance **200** receives a request from a client to access a service. In one embodiment, a virtual server or vServer **275** intercepts or otherwise receives a request from the client. In some embodiments, the virtual server **275** transparently intercepts the client's request to a service **270** or server **106**. In other embodiments, a client **102** transmits the request to the vServer **275**. In another embodiment, the vServer **275** determines from the request that the request is for one or more services under management by the appliance **200**. In one embodiment, the vServer **275** intercepts or receives the request via a SSL VPN connection between the client and the appliance **200**.

At step **475**, the appliance **200** determines which of the services to direct the client request based on determination of the load **440** for each service **270**. In one embodiment, the vServer **275** directs the request responsive to one or more load monitors **405**. In some embodiments, a vServer **275** directs, forwards or otherwise transmits the request to a service **270** with the least or smallest load. In one embodiment, the vServer **275** directs, forwards or otherwise transmits the request to a service with one of the lower determined loads. In some embodiments, the vServer **275** directs, forwards or otherwise transmits the request to the service previously handling requests from the client **102**. In one embodiment, the vServer **275** transmits the request to the previously used service if the load of the service is within a predetermined threshold. In some embodiments, the vServer **275** transmits the request to the first available service in a list with a determined load within a predetermined threshold.

In another embodiment, a vServer **275** directs, forwards or otherwise transmits the request to a service **270** using a round robin technique, or weighted round robin. In yet another embodiment, the vServer **275** directs the request to a service based on one or more metrics, such as appliance collected metrics **410** or device provided metrics **420**. For example, in some embodiments, the vServer **275** directs the request to a service based on one or more of the following: least response or round trip time, least number of connections, least number of packets, and least bandwidth. In yet other embodiments, the vServer **275** directs the request to a service based on one or more device provided metrics **430**, such as CPU, memory and disk resource usage. In another example, the vServer **275** directs the request to a service based on service resource usage on the server, such as system resource usage by an application or session of the application.

In some embodiments, a vServer **275** may not direct a request to a service **270** in which a metric for the service **270** has exceeded a threshold **437**, such as a user configured threshold **437**. In other embodiments, a vServer **275** may not direct to a request to a service **270** if more than one threshold **437** of the metrics for the service has been exceeded. In yet another embodiment, a vServer **275** may direct a request to a service **270** if a metric threshold **437** has been reached or exceeded. For example, if one metric threshold **437** of a plurality of thresholds **437** has been exceeded, then the vServer **275** may still direct the request to the service if the other metric thresholds have not been reached.

In still other embodiments, the appliance **200** may determine from load monitoring that a metric of a first vServer **275**A has reached a threshold **437**. In response to the determination, the appliance **200** may spillover management of the services **270**A-**270**N to a second virtual server, or vServer **275**B. In one embodiment, the second virtual server **275**B may be a backup server. In some embodiments, the second virtual server **275**B is established in response to detecting the first virtual server **275**A has reached one or more thresholds. In another embodiment, the second virtual server **275**B may be established and running on the appliance **200**.

At step **480**, the appliance transmits the client request to the service determined by the appliance at **475**. In one embodiment, the appliance **200** transmits the client request in a manner transparent to the service **270** such that the request appears to have been sent from the client instead of the appliance **200**. For example, the appliance **200** may act as a transparent or intercepting proxy for the client **102**. In other embodiments, the appliance **200** acts as a non-transparent proxy and transmits the request to the service on the client's behalf. In some embodiment, the vServer **275** transmits the request to a service **270**. In other embodiments, a backup vServer **275** transmits the request to the service. In yet other embodiments, a second vServer **275** transmits the request to the service.

E. Global Server Load Balancing Among Heterogeneous Device

Referring now to FIGS. **5**A-**5**C, systems and methods for load balancing a plurality of heterogeneous devices are depicted. The appliance **200** described herein may be deployed to load balance a plurality of services and load balancing devices. A first appliance **200** may communicate with a second appliance **200**A of the same type via a predetermined metric exchange protocol (MEP). The first appliance **200** obtains via the MEP protocol metrics to use for determining a load for the second appliance **200**A. Other devices of a different type than the first appliance may be deployed in the network to perform local load balancing, such as for a server farm. These devices may not communicate via the MEP protocol of the first appliance **200**. Instead, these other device may provide metrics via a network management protocol, such as a Simple Network Management Protocol (SNMP). Using the techniques described in conjunction with FIGS. **4**A and **4**B, the first appliance **200** obtains metrics from these heterogeneous devices via the network management protocol. With metrics obtains via the MEP protocol from devices of the same type and metrics obtained via a network management protocol from device of a different type, the appliance **200** may uses these combined metrics to determine a load across these heterogeneous devices and to direct request to one of the devices based on the load.

Referring now to FIG. **5**A, an example embodiment of a network environment for load balancing heterogeneous devices, including servers and local or other load balancing devices, is depicted. In brief overview, a network environment includes a plurality of different types of load balancing devices and servers. The appliance **200** is configured as a global load balancing device to load balance the plurality of

load balancing devices and servers. Each of the load balancing devices may perform local load balancing to one or more services **270**A-**270**N. For example, a first set of load balancing appliances **200**A-**200**N of the same type may perform local load balancing of services or servers on a first network **104**. These appliances **200**A-**200**B may be of the same type of the global load balancing appliance **200**. Or in some cases, local load balancing appliance **200**A-**200**N are designed and constructed to communicate metrics and other information via a metric exchange protocol **540**. A second type of load balancing appliances **500**A-**500**N may perform local load balancing for one or more services **270**A'-**270**N' on a second network **104'**. These load balancing appliances **500**A-**500**N may be of a different type than the first type of appliance **200**A-**200**N and/or the global load balancing appliance **200**. The appliance **500**A-**500**N may operate or execute one or more virtual servers or vServers **275**A-**275**N. Appliance **500**A-**500**N may not be designed to communicate via the MEP protocol **540** of appliances **200**-**200**N. Instead these appliances **500**A-**500**N may provide metrics via a network management protocol, such as SNMP. The global load balancing appliance **200** may also perform load balancing for one or more services or servers, such as a server farm **38**. Each of the servers or services may be of a different type, such as an HTTP service and an FTP service.

In view of FIG. **5**A, the plurality of appliances, servers, and services may be deployed in a hierarchical fashion. The first appliance **200** may be the global load balancing appliance at the top of the hierarchy to manage a plurality of other appliances **200**A-**200**N, **500**A-**500**N and servers. In one case, the appliance **200** manages one or more servers **106** or service **270**A-**270**N directly. In another case, the appliance **200** manages one or more appliances **200**A-**200**N, **500**A-**500**N, which in turn manages one or more servers **106** or services **270**A-**270**N. An appliance managed by the first appliance **200** may manage a second appliance, which in turns manages one or more services or servers.

By way of example in view of various load balancing products, the global load balancing appliance **200** may be any of the product embodiments referred to as NetScaler manufactured by Citrix Systems, Inc. The appliances **200**A-**200**N may also be a NetScaler device configured to perform local load balancing of one or more services **270**A-**270**N. As the appliances **200**A-**200**N are of the same type as the global load balancing appliance **200**, these appliances are designed and constructed to communicate via a predetermine protocol or and/or communication model referred to as metric exchange protocol. The appliance **200**A-**200**N may be configured to provide metric information at a predetermined frequency to appliance **200**. One or more of the appliances **500**A-**500**N may comprise another type of load balancing device, such as a BigIP load balancing device manufactured by F5 Networks, Inc. Another one or more of the appliances **500**A-**500**N may comprise a different type of load balancing device, such as the AppDirector appliance manufactured by Radware, LTD. In some cases, one or more of the appliances **500**A-**500**N may comprise a Cisco load balancing device. In other cases, one or more of the appliances **500**A-**500**N may comprise a Nortel load balancing device. Any one or more of these appliances **500**A-**500**N may not be designed or constructed to communicate with appliance **200** via the MEP protocol **540**. Although the example is generally described above as Citrix NetScaler appliance **200** providing global load balancing device, any other type of load balancing device may be used.

Instead of using MEP **540**, each of these different appliances **500**A-**500**N may provide metric information via a network management protocol, such as SNMP. As illustrated in FIG. **5**A, these appliances **500** may include an agent **416** for providing object identifiers **422**A-**422**N via an MIB **417**. Further to this example embodiment and as discussed in conjunction with FIGS. **4**A and **4**B, the appliance **200** using a manager/agent communication model may query any of these appliances **500**A-**500**N via a network management protocol to identify, collect and monitor objects identified via the MIB **417**. In some cases, the appliance **200** may use SNMP to communicate with one or more appliance **500**A-**500**N. In other cases, the appliance **200** may use another type of network management protocol to communication another one or more of the appliances **500**A-**500**N. In still another case, the appliance **200** may use a third type of network manager protocol to communicate with a further set of one or more appliances **500**A-**500**N.

Appliances **200**A-**200**N may be considered homogenous or the same type of appliance or device as appliance **200**. In one embodiment, the appliances **200**A-**200**N is the same product family of the appliance **200**. In another embodiment, the appliance **200**A-**200**N is a version of the same device of the appliance **200**. In one case, the appliances **200** and **200**A-**220**N are manufactured by the same company. In some embodiments, the appliances **200**A-**200**N and appliance **200** are configured, designed and constructed to communicating using a predetermined protocol and/or communication model. In one embodiment, the appliances **200**A-**200**N and appliance **200** are configured, designed and constructed to use a proprietary or custom protocol and/or communication model.

Appliances **500**A-**500**N may be considered heterogeneous or a different type of appliance or device as appliance **200**. In one embodiment, the appliances **500**A-**500**N are manufactured by a different company than appliance **200**. In some embodiments, the appliances **500**A-**500**N and appliance **500** are not specifically designed to communicate using a predetermined protocol and/or communication model. In one embodiment, the appliances **500**A-**500**N and appliance **200** are not configured, designed and constructed to use a proprietary or custom protocol and/or communication model. In some cases, appliances **500**A-**500**N use a network management protocol instead of using a proprietary protocol for providing metrics to other devices, applications or services.

Referring now to FIG. **5**B, an embodiment of the appliance **200** for identifying, collecting and monitoring metrics obtained from heterogeneous network devices and servers with a plurality of protocols is depicted. The appliance **200** may have one or more virtual servers **275**A-**275**N configured, constructed or designed to provide load balancing of the plurality of devices over one or more networks **104**, **104'**, **104''**. The appliance **200** may use one or more load monitors **405**A-**405**N to monitor the load of each of the heterogeneous devices. In one embodiment, the appliance **200** monitors the load of appliances **200**A-**200**N. The appliance **200** and/or load monitor **405** uses the MEP protocol **540** to obtain metrics from one or more of the appliances **200**A-**200**N. In another embodiment, the appliance **200** monitors the load of appliance **500**A-**500**N. In other embodiments, the appliance **200** monitors the load of one or more serves **106**. In still another embodiment, the appliance **200** monitors the load among servers in a server farm **38**. The appliance **200** may use one or more network management protocols to obtain metrics from server **106**, server farm **38**, and appliances **500**A-**500**N.

The appliance **200** collects metrics via the MEP protocol **540** and network management protocols from a wide variety of heterogeneous devices, such as appliances **500**A-**500**N and servers **106**, and homogenous devices **200**A-**220**N. The appliance **200** stores the metrics in a GSLB (Global Server

Load Balancing) or global metrics table **530** comprising any type and form of data storage element, such as a file, database, object or data structure in memory and/or on disk. The vServers **275** and/or load monitors **405** use one or more of the metrics from the GSLB metrics **530** to provide global load balancing of servers, server farms, virtual servers, and load balancing devices.

The appliance **200** may collect and monitor metrics obtained via a MEP protocol **540** from one or more appliance **200**A-**200**N and store them in a MEP based metrics table **510**A-**510**N. In one embodiment, the appliance **200** uses a first type or first version of a MEP protocol **540** to obtain metrics from a first appliance **200**A and stores the metrics in a first table **510**A. In another embodiment, the appliance **200** uses a second type or second version of a MEP protocol **540'** to obtain metrics from a second appliance **200**N and stores the metrics in a second table **510**N.

The appliance **200** may collect and monitor metrics from appliances **500**A-**500**N using any type and form of network management protocol (NMP) and store the metrics in a NMP based metrics table **520**A-**520**N. In one embodiment, the appliance **200** uses a SNMP protocol and communication model to obtains metrics from a second type of appliance **500**A and stores the metrics in a NMP based metric table **520**A. In some embodiments, the appliances **200** uses a second type of network management protocol, such as CIMP, to obtain from a second or third type of appliance **500**N and stores the metrics in a NMP based metric table **520**N. In some embodiments, appliance **500**A is a different type of appliance than appliance **500**N but both appliances support the same network management protocol for providing metrics.

The appliance **200** may also collect and monitor metrics from a server **106** and/or server arm **38** using any type and form of network management protocol (NMP) and store the metrics in a NMP based metrics table **520**A'-**520**N'. In one embodiment, the appliance **200** uses the same network management protocol, such as SNMP, for obtaining metrics from a server **106** as used for obtaining metrics from one of the appliances **500**A-**500**N. In another embodiments, the appliance **200** uses a different type of network management protocol for obtaining metrics from the server than is used by the appliance **200** for obtaining metrics from an appliance **500**.

The appliance **200** may store metrics for the GSLB metrics **520** in a separate table for each device. For example, the appliance **200** may store metrics for a first appliance **200**A in a first metrics table **510**A, and metrics from a second appliance **520**A in a second metrics table **520**A. The appliance **200** may store metrics from a server **106** in a server metrics tables **520**A'. In another embodiment, the appliance **200** stores metrics from a server farm **38** to a metrics table **520**N' for the server farm.

The appliance **200** may store metrics for the GSLB metrics **520** in a separate table for each type of protocol. For example, the appliance **200** may store all MEP based metrics from a plurality of appliances **200**A-**200**N in a first metrics table. In some embodiments, the appliance **200** stores a first type or version of MEP protocol based metrics in a first table **510**A and a second type or version of an MEP protocol in a second table **510**N. The appliance **200** may store all SNMP based metrics from one or more appliances **500**A-**500**N in a second metrics table. In another example, the appliance may store metrics from a second type of network management protocol from one or more appliances **500**A-**500**N to a third metrics table.

The GSLB metrics **530** may comprise any type and form of data, statistics, status or information related to or associated with the operational and/or performance characteristics of the appliance **200**, **500**, a server **106** or server farm **38**. The global metrics **530** may comprise any type and form of data, statistics, status or information related to the network of the appliance **200**,**500**, and/or server **106** or server farm **38**. The global metrics **530** may comprise any type and form of data, statistics, status or information related to the services **270**A-**270**N load balanced by the appliance **200**A-**200**N, **500**A-**500**N. In some embodiments, the global metrics **530** comprises operational and/or performance data on any client **102** and/or server **106** connected to the appliance **200**A-**200**N, **500**A-**500**N. In one embodiment, the appliance **200**A-**200**N, **500**A-**500**N determines operational and/or performance information about any client **102** or server **106** it is connected to or servicing, and creates metrics on these clients **102** and/or server **106**. In this embodiment, the appliance **200**A-**200**N, **500**A-**500**N may provide these metrics to the global load balancing appliance **200**.

In some embodiments, the operational and/or performance characteristic provides a metrics includes information on any of the following for an appliance or server 1) load; 2) numbers and types of connections, 3) resource usage, 4) resource availability, 5) number of requests outstanding, 6) number of requests transmitted, 7) number of clients servicing, 8) response time information, including average and historical response times, 9) errors, status, performance or bandwidth of a connection, and 10) number of sessions, and states or status thereof. In another embodiment, the metrics **530** includes information on any IP or network layer information of the appliance **200**A-**200**N, **500**A-**500**N, or the connections of the appliance **200**A-**200**N, **500**A-**500**N, or of the clients and/or servers serviced by the appliance **200**A-**200**N, **500**A-**500**N. For example, the information provided via metrics **530** may include a routing table of the appliance **200**A-**200**N, **500**A-**500**N for performing network address translation, such as for an SSL VPN connection.

Via the configuration interface **425**, a user may select one or more metrics **430** from the global metrics **530** to use for load monitoring and determining the load **440**. The appliance **200** may receive information identifying a user selection of one or more metrics from the global metrics **530**. The appliance may receive a user selection of one or more MEP based metrics **510** of a first type of appliance. The appliance may receive a user selection of one or more NMP based metrics **520** of a second type of appliance. The appliance may also receive a user selection of one or more NMP based metrics **520'** for any server or server farm. The user may select any combination of metrics **430** from the global metrics **530** to configure the appliance **200** to perform load balancing of heterogeneous devices according to the user selected metrics.

In one embodiment, the appliance **200** uses appliance established metrics in combination with any one or more of the user selected metrics **430** for load balancing. For example, the appliance **200** may collect and monitor the number of connections, response time, bandwidth and numbers of packets for any appliance **200**, **500** or server **106** and use these metrics with any user selected metrics for load balancing. Via the configuration interface **425** and as also discussed in conjunction with FIGS. **4**A and **4**B, the appliance **200** may receive information from the user identifying, designating or establishing weights **435** and/or thresholds **437** for any appliance established metrics and/or user selected metrics.

Referring now to FIG. **5**C, an embodiment of steps of a method **550** for performing global load balancing among heterogeneous devices is depicted. In brief overview, at step **555**, the appliance **200** identifies a plurality of metrics from heterogenous devices to use for load balancing by the appliance. At step **560**, the appliance **200** obtains metrics from one

or more homogenous appliances **200**A-**200**N or appliances of the same type as the first load balancing appliance **200**. At step **565**, the appliance **200** obtains metrics from heterogenous devices, such as appliances **500**A-**500**N and/or servers **106**, via a network management protocol, such as SNMP. At step **570**, the appliance determines a load of one or more of the plurality of appliances, servers, and/or service managed by the appliance **200** based on the metrics collects at step **560** and step **565**. At step **575**, the appliance receives a client request to access a service. At step **580**, the appliance determines based on the load one of the appliances **200**A-**200**N, **500**A-**500**N or one of the servers to which to direct the client request. At step **580**, the appliance **200** transmits the request to the device, appliance or service selected in accordance with the determined load.

In further details, at step **555**, the appliance **200** identifies metrics to collect and monitor for load balancing one or more appliances **200**A-**200**N, **500**A-**500**N, servers **106** or services **270**A-**270**N. In one embodiment, the appliance **200** provides or identifies one or more appliance collected metrics **410** as described in conjunction with FIGS. **4**A and **4**B. For example, a table **410** may identify metrics collected by the appliance **200**. In another embodiment, the appliance **200** provides one or more predetermined tables of appliance provided metrics **510** or **520**, such as for an appliance of Citrix, F5, Cisco, or Radware. In other embodiments, the appliances **200** identifies one or more metrics to collect via a network management protocol in an object or variable database, such as an MIB **417** for SNMP. In one embodiment, the appliance provides a preconfigured or preinstalled MIB **417** for a predetermined appliance **200**A-**200**N, **500**A-**500**N, server **106** or service **270**.

In some embodiments, the appliance **200** queries an appliance **200**A-**200**N, **500**A-**500**N, server **106** or service **270** to determine available metrics to collect and/or monitor. For example, in one embodiment, the appliance **200** queries an appliance, server or service for available object identifiers **422**A-**422**N. In another embodiment, the appliance **200** uses a network management protocol, such as SNMP, to query for the identification of objects in a MIB **417**. In yet another embodiment, a user via the configuration interface **425** identifies one or more object identifiers **422**A-**422**N to collect and/or monitor from a appliance **200**A-**200**N, **500**A-**500**N, server **106** or service **270**. In some embodiments, the user via the configuration interface **425** identifies one or more of the global metric **530** to collect and/or monitor from any one of the heterogenous device under management.

At step **560**, the appliance **200** collects and/or monitors metrics **510**A-**510**N from one or more appliances **200**A-**200**N via a MEP protocol **540**. In some embodiments, the appliances **200**A-**200**N are of the same type or homogenous with the appliance **200**. In one embodiment, the appliance **200** collects and/or monitors metrics **510** established, determined or otherwise selected by the appliance. In another embodiment, the appliance **200** collects and/or monitors metrics **510** established, determined or otherwise selected by a user. In some embodiments, the appliance **200** uses a first type or version of the MEP protocol **540** to collect metrics from a first appliance **200**A and a second type or version of the MEP protocol **540'** to collect metrics from a second appliance **200**N.

One or more load monitors or monitoring agents **405**A-**405**N of the appliance **200** may be configured, constructed or implemented to identify, collect and/or monitor metrics via MEP protocol **540** from one or more appliances **200**A-**200**N. A first load monitor **405**A may collect and monitor metric values from a first appliance **200**A. A second load monitor **405**N may collect and monitor metric values from a second appliance **200**N. A third load monitor **405** may collect and monitor metric values from the first and second appliances **200**A-**200**N. A load monitor **405**A-**405**N may collect and/or monitor metrics on any type of schedule or predetermined frequency. In some embodiments, the load monitor **405** collects metrics responsive to the detection of an event.

At step **565**, the appliance **200** collects and/or monitors metrics **520**A-**520**N' from one or more appliances **500**A-**500**N, servers or a server farm any type and form of network management protocol. In some embodiments, the appliances **500**A-**500**N are a different type or heterogeneous with the appliance **200**. In other embodiments, one or more of the appliances **500**A-**500**N are of a different type or heterogenous with one or more of the other appliances **500**A-**500**N. In one embodiment, the appliance **200** collects and/or monitors metrics **520** established, determined or otherwise selected by the appliance. In another embodiment, the appliance **200** collects and/or monitors metrics **520** established, determined or otherwise selected by a user. In some embodiments, the appliance **200** uses a first type or version of a network management protocol, such as SNMP, to collect metrics from a first appliance **500**A and a second type or version of a network management protocol, SNMP or CIMS, to collect metrics from a second appliance **500**N.

One or more load monitors or monitoring agents **405**A-**405**N of the appliance **200** may be configured, constructed or implemented to identify, collect and/or monitor metrics via a network management protocol from one or more appliances **500**A-**500**N. A first load monitor **405**A may collect and monitor metric values from a first appliance **500**A. A second load monitor **405**N may collect and monitor metric values from a second appliance **500**N. A third load monitor **405** may collect and monitor metric values from a server **106** or server farm **38**. In other embodiments, multiple monitors **405**A-**405**N may collect and/or monitor metrics from a plurality of appliances **500**A-**500**N and/or servers **106**. A load monitor **405**A-**405**N may collect and/or monitor any of the metrics **520**A-**520**N on any type of schedule or predetermined frequency. In some embodiments, the load monitor **405** collects metrics **520**A-**520**N' responsive to the detection of an event.

At step **570**, the appliance determines a load for each of the one or more appliances **200**A-**200**N, **500**A-**500**N, servers, server farm or services. In some embodiments, a vServer **275** determines the load **440** for each service **270** via metric information collected and monitored by a load monitor **405**. In another embodiment, the load monitor **405** determines the load **440** for appliance, server or service being monitored.

The appliance **200**, vServer **275** and/or load monitor **405** may determine the load **440** using a user selected metric **430** weighted by a user designated weight **435**. In some embodiments, the appliance **200** and/or load monitor **405** determines the load **440** using a plurality of user selected metrics **430** weighted by user designated weights **435**. In yet another embodiment, the appliance **200** and/or load monitor **405** determines the load using a user selected metric **430** and user identified weight **435** and an appliance established metric **410** and an appliance established weight **435**. In further embodiments, the appliance **200** determines the load **440** by summing a weighted load for each metric. For the embodiment of multiple monitors **405**A-**405**N per service **270**, the appliance **200** may determine the load for an appliance, server or service by assigning a weight to each monitor and computing weighted load across all the monitors **405**. In yet another embodiment, the appliance may determine the load for an appliance, server or service by assigning a weight to each of the appliance, service or service.

In some embodiments, a load monitor **405** determines that a metric **530** for an appliance, server or service has reached or exceeded a threshold **437**. In other embodiments, a load monitor **405** determines that a metric **530** for an appliance, server or service is within a threshold **437**. In one embodiment, the load monitor **405** uses an appliance established or provided threshold for a metric **530**. In another embodiment, the load monitor **405** uses a user specified or configured threshold **437**.

At step **575**, the appliance **200** receives a request from a client to access a service. In one embodiment, a virtual server or vServer **275** of the appliance **200** intercepts or otherwise receives a request from the client. In some embodiments, the virtual server **275** transparently intercepts the client's request to a service **270** or server **106**. In other embodiments, a client **102** transmits the request to the vServer **275**. In another embodiment, the vServer **275** determines from the request that the request is for one or more services under management by the appliance **200**. In one embodiment, the vServer **275** intercepts or receives the request via a SSL VPN connection between the client and the appliance **200**.

At step **580**, the appliance **200** determines which of the appliances **200**A-**200**N, servers **106** or services **270**A-**270**N to direct the client request based on determination of the load **440** for each of the appliances **200**A-**200**N, servers **106** or services **270**A-**270**N. In one embodiment, the vServer **275** directs the request responsive to one or more load monitors **405**. In some embodiments, a vServer **275** directs, forwards or otherwise transmits the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service with the least or smallest load. In one embodiment, the vServer **275** directs, forwards or otherwise transmits the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service with one of the lower determined loads. In some embodiments, the vServer **275** directs, forwards or otherwise transmits the request to the s an appliance **200**A-**200**N, **500**A-**500**N, server or service previously handling requests from the client **102**. In one embodiment, the vServer **275** transmits the request to the previously used an appliance **200**A-**200**N, **500**A-**500**N, server or service if the load for the appliance **200**A-**200**N, **500**A-**500**N, server or service is within a predetermined threshold. In some embodiments, the vServer **275** transmits the request to the first available an appliance **200**A-**200**N, **500**A-**500**N, server or service in a list with a determined load within a predetermined threshold.

In another embodiment, a vServer **275** directs, forwards or otherwise transmits the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service using a round robin technique, or weighted round robin. In yet another embodiment, the vServer **275** directs the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service based on one or more metrics, such as appliance collected metrics **410** or device provided metrics **420**. For example, in some embodiments, the vServer **275** directs the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service based on one or more of the following: least response or round trip time, least number of connections, least number of packets, and least used bandwidth. In yet other embodiments, the vServer **275** directs the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service based on one or more device provided metrics **530**, such as CPU, memory and disk resource usage. In another example, the vServer **275** directs the request to an appliance **200**A-**200**N, **500**A-**500**N, server or service based on resource usage on or of an appliance **200**A-**200**N, **500**A-**500**N, server or service.

In some embodiments, a vServer **275** may not direct a request to an appliance **200**A-**200**N, **500**A-**500**N, server or service in which a metric for the service **270** has exceeded a threshold **437**, such as a user configured threshold **437**. In other embodiments, a vServer **275** may not direct to a request to an appliance **200**A-**200**N, **500**A-**500**N, server or service if more than one threshold **437** of the metrics **530** for the appliance **200**A-**200**N, **500**A-**500**N, server or service has been exceeded. In yet another embodiment, a vServer **275** may direct a request to an appliance **200**A-**200**N, **500**A-**500**N, server or service even if a metric threshold **437** has been reached or exceeded. For example, if one metric threshold **437** of a plurality of thresholds **437** has been exceeded, then the vServer **275** may still direct the request to the appliance **200**A-**200**N, **500**A-**500**N, server or service if the other metric thresholds have not been reached.

In still other embodiments, the appliance **200** may determine from load monitoring that a metric of a first GSLB vServer **275**A has reached a threshold **437**. In response to the determination, the appliance **200** may spillover management of the appliances **200**A-**200**N, **500**A-**500**N, servers or services to a second GSLB virtual server, or vServer **275**B. In one embodiment, the second virtual server **275**B may be a backup GSLB server. In some embodiments, the second GSLB virtual server **275**B is established in response to detecting the first GSLB virtual server **275**A has reached one or more thresholds. In another embodiment, the second GSLB virtual server **275**B may be established and running on the appliance **200**.

At step **580**, the appliance **200** transmits the client request to the appliance **200**A-**200**N, **500**A-**500**N, server or service identified by the appliance at **585**. In one embodiment, the appliance **200** transmits the client request in a manner transparent to the appliance **200**A-**200**N, **500**A-**500**N, server or service such that the request appears to have been sent from the client instead of the appliance **200**. For example, the appliance **200** may act as a transparent or intercepting proxy for the client **102**. In other embodiments, the appliance **200** acts as a non-transparent proxy and transmits the request to the appliance **200**A-**200**N, **500**A-**500**N, server or service on the client's behalf. In some embodiment, the vServer **275** transmits the request to the appliance **200**A-**200**N, **500**A-**500**N, server or service. In other embodiments, a backup vServer **275** transmits the request to the appliance **200**A-**200**N, **500**A-**500**N, server or service. In yet other embodiments, a second vServer **275** transmits the request to the appliance **200**A-**200**N, **500**A-**500**N, server or service

Although the systems and methods of FIGS. **5**A-**5**C are generally discussed in the context of global server load balancing, these systems and methods may be used for local load balancing. The appliance **200** may use metrics obtained from heterogeneous devices, servers, or services using a plurality of protocols to load balance one or more services or servers. Using the techniques described herein, the appliance **200** is configurable and flexible to obtain metrics from any network resource—system, sub-system, application, service, device, etc—using either a metric exchange protocol supported by the appliance and/or a more general network management protocol supported by the network resource. Additionally, the appliance **200** is configurable to allow users to select any combination of available metrics from these heterogenous network resources to perform load monitoring and load balancing of one or more services.

F. Global Server Load Balancing Based on SSL VPN Users

Referring now to FIG. **6**A, a block diagram of an embodiment of a system for global server load balancing across a plurality of sites based on a number of Secure Socket Layer Virtual Private Network (SSL VPN) users is illustrated. In brief overview, a Global Server Load Balancing virtual server

(GSLB) of appliance **200/500** balances network traffic across multiple appliances **200/500**. Appliance **200/500**A is located at site A and balances the network traffic received from the GSLB appliance **200/500** across a group of servers **106** deployed at site A. Similarly, appliance **200/500**B is located at site B and balances the network traffic received from the GSLB appliance **200/500** across a group of servers stationed at site B. Site A servers, servers **106**A-B, receive the network traffic balanced by appliance **200/500**A. Site B servers, servers **106**C-D, receive the network traffic balanced by appliance **200/500**B.

Any of the servers at any of the sites may service any users, including SSL VPN users. By way of example, servers **106**A-D provide service to SSL VPN users **650**A-N and users **660**A-N, wherein N can be any number. GSLB appliance **200/500** includes a GSLB vServer **275** comprising a SSL VPN Load Balancer or load balancing scheme **605** which load balances requests based on SSL VPN metrics or statistics. Appliances **200/500** include LB vServers **275** and SSL VPN Managers **620**.

Each of the appliances at the site may have an SSL VPN Manager **620** which identifies and/or monitors a number of users accessing services at the site, including a number of SSL VPN users. SSL VPN Manager **620**A of appliance **200/500**A may identify users **660** and SSL VPN users **650** from the site A. Similarly, SSL VPN Manager **620**B of the appliance **200/500**B identifies users **660** and SSL VPN users **650** from the site B. GSLB appliance **200/500** may communicate with appliances **200/500** via a number of protocols, such as MEP **540** or SNMP protocols. GSLB **200/500** appliance may receive from appliances **200/500** information identifying the number of SSL VPN users **650** at each of the sites A and B. GSLB appliance **200/500** may determine via SSL VPN load balancing **605** which appliance **200/500** to receive an incoming request based on the number of SSL VPN users **650** at each of the sites A and B.

In further overview, FIG. **6**A depicts a GSLB appliance **200/500** load balancing incoming network traffic across appliances **200/500** that are positioned at a plurality of sites. GSLB appliance **200/500** may be any type and form of intermediary that balances network traffic across any number of devices on the network, such as appliances **200**, appliances **500**, servers **106** or clients **102**. GSLB appliance **200/500** may be any appliance **200** or appliance **500** load balancing network traffic across a plurality of other appliances **200** or appliances **500**. In some embodiments, GSLB appliance **200/500** is an intermediary forwarding communication between any number of clients **102** and any number of appliances **200** or appliances **500**. In some embodiments, GSLB appliance **200/500** is an appliance **200**. In other embodiments, GSLB appliance **200/500** is an appliance **500**. In yet further embodiments, GSLB appliance **200/500** is an appliance that includes any functionality of any appliance **200** and appliance **500** described in conjunction with previous figures. In addition to the aforementioned LB vServer **275**, GSLB appliance **200/500** may further comprise SSL VPN load balancing **605**. In some embodiments, GSLB appliance **200/500** comprises any components or any functionality of any embodiments of appliance **200**, appliance **500**, client **102** or server **106**. The GSLB appliance **200/500** may further comprise functionality to communicate with any appliance **200** or any appliance **500** via any type of protocol, such as MEP protocol or SNMP protocol.

GSLB vServer **275** may be any embodiment of vServer **275** described herein. The GSLB vServer **275** may further comprise any functionality to balance network traffic across a plurality of appliances **200/500**. GSLB vServer **275** may perform global server load balancing by load balancing a plurality of appliances **200**, appliances **500** or appliances **200/500**. GSLB vServer **275** may also utilize any one or more of a plurality of schemes for load balancing of the devices, such as least connection, round trip times, round robin, least response time, least bandwidth, least network packets and proximity. In some embodiments, GSLB vServer **275** may comprise a SSL VPN load balancing scheme **605** for load balancing requests and devices based on SSL VPN user metrics. In some embodiments, the GSLB appliance may use the SSL VPN user metric or scheme **605** in combination any one or more other load balancing algorithms, such as least connection, round trip times, round robin, least response time, least bandwidth, least network packets and proximity.

SSL VPN load balancer or load balancing scheme **605** may comprises any function, operations, logic or rule for load balancing based on any type and form of statistics or metrics about SSL VPN users, such as current number of SSL VPN users. The metrics or statistics may include information or data on a number of SSL VPN session, a number of SSL VPN connections and/or a number of SSL VPN users. The SSL VPN load balancer **605** may be any unit, device, function, software, algorithm or a component of a GSLB vServer **275** that provides functionality to determine to which devices to forward a request based on SSL VPN users. SSL VPN load balancing scheme **605** may utilize information identifying SSL VPN users on any number of sites, such as sites A and B, to determine which device to forward a request received by the GSLB appliance **200/500**. SSL VPN Scheme **605** may receive from the appliances **200/500** information relating the number of SSL VPN users on all the servers **106** load balanced by the appliances **200/500**, and in response to the information received determine which of the appliances **200/500** will receive the incoming request. The SSL VPN load balancing scheme **605** may determine which appliance **200/500** to forward a request received by the GSLB appliance **200/500** based on the type of connection the client **102** is requesting or is currently connected with, such as SSL VPN connection. For example, GSLB appliance **200/500** may receive a request from a client **102** which may already be using an SSL VPN session.

A site, such as sites A or B, may be any location(s) or deployment comprising one or more appliances **200/500** and one or more servers **106** being load balanced by the one or more appliances **200/500**. For example, a site may be a data center. In another example, a site may be an office, such as a branch office. A site may be a geographical location in which a group of servers **106** and appliances **200/500** are located. A site may be a plurality of geographical locations over which a group of servers **106** and appliances **200/500** are spread out. In some embodiments, a site is a room housing a group of servers and an appliance **200/500**. In other embodiments, a site is a group of servers **106** located over a number of areas being load balanced by an appliance **200/500**. In some embodiments, a site is any group of servers **106** being load balanced by one or more appliances **200/500**. A site may be one or more servers **106**.

Appliances **200/500**, such as appliances **200/500**A or appliance **200/500**B may be any embodiment of appliance **200** or appliance **500** described herein. In some embodiments, an appliance **200/500** comprises an SSL VPN manager **620**. The SSL VPN manager **620** may comprise any function, operations or logic for monitoring, counting and/or gathering information relating to SSL VPN connections, SSL VPN sessions or SSL VPN users. The SSL VPN manager **620** comprises software, hardware or a combination of software and hardware. The SSL VPN manager may comprise an

application, program, library, script, task, process, service, thread or any form and set of executable instructions.

The SSL VPN manager **620** may obtains, establish determine or otherwise provides any type and form of metrics or statistics related to SSL VPN users and/or SSL VPN sessions. In some embodiments, SSL VPN manager **620** determines a count of a number of SSL VPN users accessing the site. In some embodiments, SSL VPN manager **620** determines a count of a number of SSL VPN users accessing servers via the appliance. In some embodiments, SSL VPN manager **620** determines a count of a number of SSL VPN on each of the servers managed by the appliance. In some embodiments, SSL VPN manager **620** monitors and determines information relating SSL VPN users, SSL VPN sessions or SSL VPN connections only on the servers load balanced by the appliance **200/500**. In yet further embodiments, SSL VPN manager **620** maintains statistics, metrics or count of any SSL VPN sessions or any SSL VPN threads on any of the servers **106**.

In some embodiments, SSL VPN manager **620** determines load balancing across the plurality of servers **106** of the site in response to any of the SSL VPN user and/or session metrics or statistics. In these embodiments, the site appliance may perform local site load balancing using the SSL VPN user metrics. In other embodiments, SSL VPN manager **620** determines load balancing across the plurality of servers **106** in response to the information or metrics relating the number of SSL VPN user **650** connections and user **660** connections on any of the servers **106**.

SSL VPN manager **620** may identify any users of the site, appliance or any appliance, server or service of the site or otherwise accessed via the appliance, such as SSL VPN users **650** and users **660**. SSL VPN manager **620** may comprise information relating to any SSL VPN user **650** gathered by monitoring of the network traffic of the SSL VPN user **650** which traverses the appliance **200/500**. The SSL VPN manager **620** may comprise any information of any user within the site which appliance **200/500** services. The SSL VPN manager may distinguish and determine those users which are SSL VPN users in comparison to users that are not accessing services via SSL VPN. In some embodiments, the SSL VPN users are a subset of all users at the site. In some embodiments, a user may concurrently be both a SSL VPN user and a non-SSL VPN user. In some of these embodiments, the SSL VPN manager may count and consider the user as an SSL VPN user. In other embodiments, the SSL VPN manager may not count and consider the user as an SSL VPN user.

Still referring to FIG. **6**A, the users and SSL VPN users of the site are described. FIG. **6**A illustrates servers **106** comprising users **660** and SSL VPN users **650**. Servers **106**A-B are servers at the site A, load balanced by appliance **200/500**A of the site A. Appliance **200/500**A comprises SSL VPN manager **620**A which may identify the users **660** and SSL VPN users of the servers at site A. Appliance **200/500**B comprises SSL VPN manager **620**B which may identify the users **660** and SSL VPN users of the servers at site B. In some embodiments, the appliance **200/500** has, establishes or otherwise maintains a set of users and SSL VPN users of the appliance. In some embodiments, the users and SSL VPN users of an appliance are the same users and SSL VPN users of the servers. In other embodiments, some of the users and/or SSL VPN users of the appliance are different than some of the users and/or SSL VPN users of the servers. In some embodiments, site A may have one or more users and/or one or more SSL VPN users in common with users and/or SSL VPN users at site B. The number of users **660** and/or SSL VPN users **650** may vary at each site.

SSL VPN user **650** may be any user accessing via an SSL VPN connection or session a resource at a site, an appliance, or any server of the site or otherwise managed by the appliance. In some embodiments, SSL VPN user **650** is a user on a client **102** establishing an SSL session or communication via an SSL session. In other embodiments, SSL VPN user **650** is a user establishing an SSL session on a server **106**. In some embodiments, SSL VPN user **650** is a user establishing an SSL VPN session with the appliance **200/500** or otherwise sending communications traversing the appliance via an SSL VPN session. In some embodiments, SSL VPN user **650** is a user from a device on a first network, such as a public network, accessing a server **106** on a second network, such as private network utilizing SSL VPN. As described herein, the appliance **200/500** established and manages access between networks and locations. SSL VPN user **650** may be any user using an SSL VPN session, SSL VPN connection or any secure tunneling protocol.

User **660** may be any user accessing a resource at a site, an appliance, or any server of the site or otherwise managed by the appliance. A user may be an SSL VPN user. A user may a user not using SSL VPN. A user may be a user with an SSL VPN session and a non-SSL VPN session. In some embodiments, user **660** is a user on a client **102** connecting to the server **106**. In some embodiments, user **660** is a user of the appliance **200/500**. In some embodiments, user **660** is a user opening a plurality of connections to the server **106**. In other embodiments, user **660** is a user on the server **106** that does not utilize SSL VPN. In some embodiments, user **660** may have any number of connections on the server **106**. In other embodiments, user **660** may have any number of user sessions on the server **106**. User **660** may be any user using any computing device to communicate with the server **106**.

Referring now to FIG. **6**B, a flow diagram of embodiments of a method for global server load balancing of a plurality of sites based on a number of SSL VPN users accessing the servers is illustrated. In brief overview of method **600**, at step **605** a global server load balancing virtual server (GSLB) load balances a plurality of sites and receives a request to access a server. At step **610**, a load balancing virtual server (LB vServer) at each of the plurality of sites load balances users accesses to servers. At step **615**, a first LB vServer determines a first number of current SSL VPN users accessing servers from the first site via SSL VPN sessions and a second LB vServer determines at a second site a second number of current SSL VPN users accessing servers from the second site via SSL VPN sessions. At step **620**, the GSLB receives from the number of current SSL VPN users from the plurality of sites, such as from the first LB vServer and the second LB vServer. At step **625**, the GSLB determines to forward the request to one of the sites, such as the first LB vServer or the second LB vServer based on the current number of SSL VPN users at each site.

In further view, at step **605** a global server load balancing virtual server (GSLB) load balances multiple sites receives a request to access a server. GSLB, such as a GSLB appliance **200/500**, may receive a request to resolve a domain name. In some embodiments, GSLB receives a request to establish a SSL VPN session. GSLB, such as GSLB appliance **200/500** may receive a request from a client **102** to access a webpage or a file on one of the servers **106**. In some embodiments, GSLB receives a request from a client **102**, a server **106** or any device on a network to access an application provided by a server **106**. In some embodiments, GSLB receives a request from a plurality of clients **102** to access a streaming file, such as an audio or a video file stored on a server **106**. In some embodiments, GSLB receives a request from a user on a client

102 to log in to an email service provided by the server 106. The request received by the GSLB may be any request to access a resource or a service at any server 106. Based on the request, the GSLB load balances requests across sites using any load balancing scheme or algorithm, including but not limited to one or more of the following: least response or round trip time, least number of connections, least number of packets, and least bandwidth. In some embodiments, the GSLB load balances in accordance with SSL VPN loading balancing scheme 605 described herein. In one embodiment, the GSLB load balances across sites based on a number of SSL VPN users at each site.

At step 610, one or more load balancing virtual servers (LB vServers) at each of the sites load balances any user accesses accessing servers 106. In some embodiments, a load balancing virtual server of a particular site, such as a LB vServer 275A of appliance 200/500A, load balances traffic from users requesting access to servers 106 of the particular site, such as site A. In some embodiments, a plurality of load balancing virtual servers balance the network traffic across a plurality of groups of servers 106, each of the groups corresponding to a site load balanced by one of the load balancing virtual servers. In other embodiments, each of load balancing virtual servers corresponding to each of the sites balances network traffic across any number of servers 106 within each of the particular sites load balanced by the load balancing virtual servers. In some embodiments, a first LB vServer at a first site load balances network traffic across a first group of servers 106 at a first site. A second LB vServer at a second site may load balance network traffic across a second group of servers 106 at a second site. Similarly, a third LB vServer at a third site may load balance a network traffic across a third group of servers 106 at a third site. In some embodiments, any of the LB vServers are performing local site load balancing while the GSLB is load balancing requests across sites.

At step 615, any LB vServer of the first site determines a first number of current SSL VPN users accessing servers from the first site and any LB vServer of the second site determines a second number of current SSL VPN users accessing servers from the second site. In some embodiments, a first LB vServer determines a first number of current SSL VPN users accessing servers from the first site via one or more SSL VPN sessions. Similarly, a second LB vServer may determine a second number of current SSL VPN users accessing servers from the second site via one or more SSL VPN sessions. In other embodiments, any LB vServer of the plurality of LB vServers at the first site determines a first number of current SSL VPN users accessing servers from the first site via SSL VPN sessions. Likewise, any LB vServer of the plurality of LB vServers at the second site may determine a first number of current SSL VPN users accessing servers from the second site via SSL VPN sessions.

In yet further embodiments, one or more LB vServers at the first site determine a first number of current SSL VPN connections connected to the servers at the first site. One or more LB vServers at the second site may determine a first number of current SSL VPN connections connected to the servers at the second site. In still further embodiments, one or more LB vServers at the first site determine a first number of current SSL VPN users having sessions at servers 106. Similarly, one or more LB vServers at the second site may determine a second number of current SSL VPN users having sessions at servers 106. In some embodiments, the first number is the number of current SSL VPN sessions accessing the servers at the first site. The second number may be the number of current SSL VPN sessions accessing the servers at the second site. In other embodiments, the first number is the number of users currently connected to the servers using SSL VPN connections at the first site. The second number may be the number of users currently connected to the servers using SSL VPN connections at the second site

Any of the LB vServers or appliances may report the number of SSL VPN users based on any type and form of statistics on the SSL VPN users. In some embodiments, the number of SSL VPN users is provided as an average over any time periods. In some embodiments, the number of SSL VPN users is provides as peak number of SSL VPN users. In other embodiments, the number of SSL VPN users is provides as a range. In another embodiments, the number of SSL VPN users is provides as well as the number of SSL VPN sessions. For example, a single SSL VPN user may have multiple SSL VPN sessions. In still further embodiments, the first number is any number of users using SSL VPN to connect to one or more servers at the first site within a past predetermined time period. In some embodiments, the second number is any number of users using SSL VPN to connect to one or more servers at the second site within a past predetermined time period. The past predetermined time period may be any time period such as the prior minute, the prior hour, the prior day, the prior month or the prior year from the moment of determination of the first number.

At step 620, the GSLB receives from any of the appliances at each of the multiple sites information on the number of SSL VPN users, and/or any metrics or statistics thereof. In some embodiment, the GSLB receives from any of the LB vServers at the first site a first number of current SSL VPN users and from any of the LB vServers from the second site a second number of current SSL VPN users. GSLB, such as the GSLB appliance 200/500, may receive the first number or the second number via MEP 540 protocol. In some embodiments, GSLB receives the first number or the second number via SNMP protocol. GSLB may receive the first number or the second number via any communication means and via any communication scheme or communication protocol. The GSLB may receive the SSL VPN user information on a predetermined frequency. The GSLB may request the SSL VPN user information on a predetermined frequency. The GSLB may receive the SSL VPN user information upon changes to the information. The GSLB appliance may receive the information from an appliance of a first site at a different time or frequency than an appliance of second site. The GSLB appliance may receive the information from an appliance of a first site at a same or concurrent time or frequency as an appliance of second site. The GSLB appliance may receive the information from an appliance of a second site subsequent to an appliance of the first site.

At step 625, GSLB performs load balancing of client access across the sites based on the received SSL VPN user information using the SSL VPN load balancing scheme 605 alone or in combination with any load balancing algorithm of the appliance. The GSLB determines to forward the request to any one the LB vServers at the first site or any one of the LB vServers at the second site based on the number of SSL VPN users at each site. GSLB may determine to forward the request to one of the first LB vServer or the second LB vServer based on the first number of current SSL VPN users and the second number of current SSL VPN users. In some embodiments, GSLB determines to forward the request received by the GSLB to the first LB vServer of the first site upon determining that the number of the SSL VPN users currently connected to the servers of the first site is smaller than the number of the SSL VPN users currently connected to the servers of the second site. In other embodiments, GSLB determines to forward the request to the first LB vServer of

the first site upon determining that the number of the SSL VPN users currently connected to the servers of the first site is greater than the number of the SSL VPN users currently connected to the servers of the second site. In further embodiments, GSLB determines to forward the request to the second LB vServer of the second site upon determining that the number of the SSL VPN user sessions currently active on the servers of the first site is smaller than the number of SSL VPN user sessions currently active on the servers of the second site. In some embodiments, GSLB determines to forward the request to the second LB vServer upon determining that the number of the SSL VPN connections currently connected to the servers of the first site is smaller than the number of the SSL VPN connections currently connected to the servers of the second site. GSLB may determine to forward the request to either the first LB vServer of the first site or the second LB vServer of the second site In some embodiments, the GSLB appliance determines one or more thresholds of the number of SSL VPN users allowed or desired for a site has been reached and excluding the site from load balancing until the site no longer exceeds the threshold. In some embodiments, even though a threshold has been reached at a site, the GSLB forwards a request to the site for client, user or site persistence.

What is claimed is:

1. A method for global server load balancing a plurality of sites based on a number of Secure Socket Layer Virtual Private Network (SSL VPN) users accessing servers at each of the plurality of sites, the method comprising:

a) receiving, by a global server load balancing (GSLB) virtual server of a first appliance, a request to access a server, the GSLB virtual server load balancing a plurality of sites, each of the plurality of sites comprising a load balancing virtual server load balancing users access to servers, a plurality of the users accessing servers via an SSL VPN session, one or more of the plurality of the users having a plurality of sessions with one or more servers;

b) receiving, by the GSLB virtual server from a first load balancing virtual server of a second appliance at a first site, a first number of current SSL VPN users of a first plurality of SSL VPN and non-SSL VPN users of the second appliance, the first number of current SSL VPN users identified and maintained by the second appliance and accessing servers from the first site via SSL VPN sessions, a first load balancing virtual server of the second appliance determining a first count of the first number of current SSL VPN users distinguished from those users of the second appliance that are not accessing servers via SSL VPN;

c) receiving, by the GSLB virtual server from a second load balancing virtual server of a third appliance at a second site, a second number of current SSL VPN users of a second plurality of SSL VPN and non-SSL VPN users of the third appliance, the second number of current SSL VPN users identified and maintained by the third appliance and accessing servers from the second site via SSL VPN sessions, a second load balancing virtual server of the third appliance determining a second count of the second number of current SSL VPN users distinguished from those users of the third appliance that are not accessing servers via SSL VPN; and

d) determining, by the GSLB virtual server, to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing a number of SSL VPN users across the plurality of sites based on the first number of current SSL VPN users and the second number of current SSL VPN users.

2. The method of claim **1**, wherein one of the first number of current SSL VPN users or the second number of current SSL VPN users comprises an average number of users over a predetermined time period.

3. The method of claim **1**, wherein step (b) further comprises requesting, by the GSLB virtual server, the first number of SSL VPN users from the first load balancing virtual server via an SNMP (Simple Network Management Protocol) request, the first number of SSL VPN users identified via an object identifier, the first load balancing virtual server updating a value of an object identified by the object identifier.

4. The method of claim **1**, wherein step (b) further comprises receiving, by the GSLB virtual server of a first appliance, the first number of current SSL VPN users from the first load balancing virtual server of the second appliance via a metric exchange protocol communicated between the first appliance and the second appliance.

5. The method of claim **1**, wherein step (c) further comprises requesting, by the GSLB virtual server, the second number of SSL VPN users from the second load balancing virtual server via an SNMP (Simple Network Management Protocol) request, the second number of SSL VPN users identified via an object identifier, the second load balancing virtual server updating a value of an object identified by the object identifier.

6. The method of claim **1**, further comprising determining by the first virtual load balancer of the second appliance a first count of a first set of the first number of SSL VPN users from all users accessing the first site via the second appliance and determining by the second virtual load balancer of the third appliance a second count of a second set of the second number of SSL VPN users from all users accessing the second site via the third appliance.

7. The method of claim **1**, wherein step (d) further comprises determining, by the GSLB virtual server, a threshold of a maximum number of SSL VPN users for the first site has been reached and responsive to the determination, forwarding the request to the second site.

8. The method of claim **1**, wherein step (d) further comprises determining, by the GSLB virtual server, a threshold of a maximum number of SSL VPN users for the second as been reached and responsive to the determination, forwarding the request to the first.

9. The method of claim **1**, wherein step (d) further comprises determining, by the GSLB virtual server, to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing the number of SSL VPN users across the plurality of sites in combination with any of the following load balancing methods: least connection, least response time, least bandwidth, least packets and round trip time.

10. A system for global server load balancing a plurality of sites based on a number of Secure Socket Layer Virtual Private Network (SSL VPN) users accessing servers at each of the plurality of sites, the system comprising:

a global server load balancing (GSLB) virtual server executing on a first appliance receiving a request to access a server, the GSLB virtual server load balancing a plurality of sites, each of the plurality of sites comprising a load balancing virtual server load balancing users access to servers, a plurality of the users accessing serv-

ers via an SSL VPN session, one or more of the plurality of the users having a plurality of sessions with one or more servers;

a first load balancing virtual server executing on a second appliance at a first site providing to the GSLB virtual server a first number of current SSL VPN users of a first plurality of SSL VPN and non-SSL VPN users of the second appliance, the first number of current SSL VPN users identified and maintained by the second appliance and accessing servers from the first site via SSL VPN sessions, the first load balancing virtual server determining a first count of the first number of current SSL VPN users distinguished from those users of the first appliance that are not accessing servers via SSL VPN;

a second load balancing virtual server at a second site executing on a third appliance providing to the GSLB virtual server a second number of current SSL VPN users of a second plurality of SSL VPN and non-SSL VPN users of the third appliance, the second number of current SSL VPN users identified and maintained by the third appliance and accessing servers from the second site via SSL VPN sessions, the second load balancing virtual server of the third appliance determining a second count of the second number of current SSL VPN users distinguished from those users of the third appliance that are not accessing servers via SSL VPN; and

wherein the GSLB virtual server determines to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing a number of SSL VPN users across the plurality of sites based on the first number of current SSL VPN users and the second number of current SSL VPN users.

11. The system of claim **10**, wherein one of the first number of current SSL VPN users or the second number of current SSL VPN users comprises a peak number.

12. The system of claim **10**, wherein the GSLB virtual server of the first appliance requests the first number of SSL VPN users from the first load balancing virtual server via an SNMP (Simple Network Management Protocol) request, the first number of SSL VPN users identified via an object identifier, the first load balancing virtual server updating a value of an object identified by the object identifier.

13. The system of claim **10**, wherein the GSLB virtual server of the first appliance requests the first number of SSL VPN users from the first load balancing virtual server via an SNMP (Simple Network Management Protocol) request, the first number of SSL VPN users identified via an object identifier, the first load balancing virtual server updating a value of an object identified by the object identifier.

14. The system of claim **10**, wherein the GSLB virtual server of the first appliance receives the first number of current SSL VPN users from the first load balancing virtual server of the second appliance via a metric exchange protocol communicated between the first appliance and the second appliance.

15. The system of claim **10**, wherein the GSLB virtual server of the first appliance receives the second number of SSL VPN users from the second load balancing virtual server of the third appliance via an SNMP (Simple Network Management Protocol) request, the second number of SSL VPN users identified via an object identifier, the second load balancing virtual server updating a value of an object identified by the object identifier.

16. The system of claim **10**, wherein the first virtual load balancer of the second appliance determines a first count of a first set of the first number of SSL VPN users from all users accessing the first site via the second appliance and the second virtual load balancer of the third appliance determines a second count of a second set of the second number of SSL VPN users from all users accessing the second site via the third appliance.

17. The system of claim **10**, wherein the GSLB virtual server determines a threshold of a maximum number of SSL VPN users for the first site has been reached and responsive to the determination, forwards the request to the second site.

18. The system of claim **10**, wherein the GSLB virtual server determines a threshold of a maximum number of SSL VPN users for the second site has been reached and responsive to the determination, forwards the request to the first site.

19. The system of claim **10**, wherein the GSLB virtual server determines to forward the request to one of the first load balancing virtual server of the first site or the second load balancing virtual server of the second site by load balancing the number of SSL VPN users across the plurality of sites in combination with any of the following load balancing methods: least connection, least response time, least bandwidth, least packets and round trip time.

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